THE UNIVERSITY OF ALBERTA

RESOURCE REQUIREMENTS FOR THE PRODUCTION OF BEEF CALVES AND YEARLINGS IN THE PEACE RIVER AREA OF ALBERTA

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF AGRICULTURAL ECONOMICS

EDMONTON, ALBERTA

MAY, 1966

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Resource Requirements for the Production of Beef Calves and Yearlings in the Peace River Area of Alberta" submitted by John MacKenzie in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The study was directed toward obtaining physical input-output information on beef breeding enterprises in the Peace River area of Alberta of a type suitable for use in budget analyses and linear programming procedures. Beef production information was obtained by personal interview with 45 livestock farm operators whose beef enterprise ranged from 10 to 225 breeding females. In this study four strata were formed based on the average number of beef animal units carried during the survey year, July 1962 to July 1963. The characteristics of the area were such that many operators found it advantageous to intensify beef operations by retaining the calf crop after weaning for varying time periods. To study this source of intensification,the farms were placed into three strata based on the proportion of feeder animal units to total beef animal units. Descriptive statistics were applied to the stratified and pooled data. Land, labour, and capital resources employed in beef production were quantified. Information was obtained and analyzed on the following beef production and management practices and efficiency factors: annual production per animal unit, percent of calf crop, livestock losses, culling and replacement rates, cow-bull ratios, length of breeding season and roughage handling.

Comparison with feeding standards indicated that on the average excessive quantities of concentrate were being fed to cows, heifers, bulls, and replacement calves. Significant differences in concentrate

use were found between strata. The smaller operators, those in strata one and two, depended more heavily on greenfeed hay than did those in strata three and four. The larger operations were found to have advantages with regard to access to native pasture. Economies of scale were observed in the use of labour and livestock equipment.

Regression analysis was used to examine the enterprises for imbalance in the existing pattern of resource use. Six independent variables were used: size, roughage, concentrate, labour, shelter, and variable costs. Linear regression equations were calculated using arithmetic and logarithmic values of the variables on both a total enterprise and a per animal unit basis. The results of regression analysis supported a number of the preceding conclusions, particularly that decreasing concentrate allowances would increase profits. The size of the beef enterprise could also profitably be increased.

In general, the conclusions were that small operations employed different resource patterns than large operations and that larger operators were applying their management more skillfully. Knowledge of appropriate differences to be expected between different sized operations enables a refinement to be made in formulating livestock budgets.

ACKNOWLEDGEMENTS

I wish to express sincere appreciation to Dr. H. C. Love for his guidance, assistance, and encouragement given at every stage of this study.

Further acknowledgement is given to all members of the Department for their various contributions, and to District Agriculturists G. R. McNaughton, M. H. Jaque, E. Dobko, and F. Graves.

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INTRODUCTION

THE PROBLEM

This study examined the allocation of selected resource inputs by farmers within the beef production industry of the Peace River area of Alberta. It was initiated to develop information for improved organization of production on individual farm firms.

Extension workers and others engaged in farm enterprise organization have found the technique of budget preparation for the farm firm and family helpful in moving towards an optimum organization of resources. In the case of farms these resources included the many heterogeneous inputs normally grouped under the classical terms of land, labour, capital, and management. Various trial organizations of these inputs to produce several feasible combinations of output -- output might be any combination of hay, pork, grain, or beef -- can be examined through budgeting to derive an enterprise organization that is agreeable to the farm operator in terms of his enterprise preferences, production abilities, risk and uncertainty considerations, his tenure position, and income producing possibilities. A farm plan that meets the criterion of greater profits will agree more closely with the wishes of society than some previous plan, for society provides greater rewards for adoption of the optimum plan. Often existing resources can be combined within

an enterprise or between enterprises in ways that will increase profits but not violate other criteria of the producer.

In recent years budgeting techniques have been applied to practical farm organization problems with the aid of the technique of linear programming. Often large problems of resource recombination and enterprise selection can best be examined through use of the linear programming tool.

Another tool used by economists to determine where resource use imbalance exists is regression analysis. If certain basic relationships between production and productive inputs can be satisfactorily described (again speaking in reference only to farm planning), then it is possible to arrive at conclusions concerning the most desirable mix of inputs, providing a suitable choice indicator can be defined.[1] If the productive relationships have been somewhat less than satisfactorily described, often it is still possible to arrive at some conclusions concerning which direction resource adjustments should take.

The tools briefly outlined above have important practical application in individual enterprise and over-all farm planning.[2] Their development and use by the farm planner depends upon the availability of

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[1] Price ratios are the choice indicators used in practice most often by economists.

[2] While the application of these tools would certainly increase farm efficiency, the question of priority exists. The greatest benefits to society would be achieved by first directing our planning efforts at the most pressing problem areas of the economy providing these areas could be recognized.

information concerning input-output relationships. The physical production possibilities must be carefully defined. For example, the planner must decide what quantity and quality of product will be forthcoming from an acre of land if specified quantities of seed, fertilizer, labour, machine services, and other inputs are applied to this land. Furthermore, he would like to know what the product forthcoming will be in each case so that if prices, as choice indicators, were attached to each product and to each combination of inputs, the most profitable combination could be selected. The combinations of inputs which maximize the total physical product often vary with the environment. Thus regional differences in climate and soil characteristics influence output and the pattern of required inputs. Although climate and soil productivity change slowly over time, technological change creates the larger problem by continually widening the range of production possibilities.

Hence agricultural production economists require recent information on relationships in many localities. Ultimately if accurate planning is to be carried to the level of the individual firm, these relationships must be defined for the resources available to that firm.

This study was initiated by the Department of Agricultural Economics at the University of Alberta when information was found lacking on physical input-output relationships for beef breeding operations in various parts of Alberta. The problem was encountered during comparative studies of livestock enterprises in the Province. While some information was available for southern areas, information for northern

areas and the Peace River area in particular was lacking. Preliminary investigation revealed that conditions in the Peace River area differed sufficiently from those in the southern areas to make extrapolation of existing coefficients unreliable for the Peace River area.

Continuing prosperity in both the United States and Canada has resulted in a progressive rise in the level of living. This rise, coupled with an increased populace in these countries, and their desire for red meat products has resulted in a good demand for beef and attractive prices for the producer. As one consequence beef production has been moving into areas that previously were disadvantageous. The Peace River region was one such area that has been receiving increased attention from beef producers.[3] It seemed to offer continued possibilities for expansion, having available unused land that can be utilized for summer grazing. Though large quantities of roughage were required to winter stock, growing conditions for roughage were good. Beef production in the area was carried on primarily as a part of a general farming enterprise. The majority of cattle produced in Alberta come from farms, and expansion of beef breeding operations can be expected to develop primarily on farms.

As a developing agricultural region the Peace River area was in some

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[3] Calculations made by J.E. Fetherstonaugh in reporting cattle marketings out of the Peace River area to public stockyards and federally inspected packing plants showed a 65% increase in comparing average marketings in the five year period 1956-1960 to marketings in the period 1951-1955. Reported in Proceedings of the Peace River Agricultural Coordinating Conference. Sponsored by the Peace River Branch of the Alberta and British Columbia Institute of Agrologists and the Agricultural Institute of Canada. Beaverlodge, Alberta. Multilithed report. January 12-13, 1963.

ways unique from the rest of the province, and survey work was required to outline the differences that were present to supply a basic information useful to those working in the agricultural sector of the area.

Objectives of the Study

The chief objective was to provide physical input-output information on beef breeding enterprises in the Peace River area of Alberta suitable for use in budget analysis and linear programming procedures.[4] Examples of the type of physical input-output information desired included the following:

(1) Quantities of roughage and concentrates used by practicing operators in the area to winter and feed the different classes of livestock;

(2) Kinds and types of physical equipment required to carry on beef production in the area;

(3) Quantities of labour required during different months of the year.

(4) Some indication of the quantities of land involved in summer grazing and winter roughage production;

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[4] Such data used in conjunction with information on cropping possibilities and other livestock enterprises could be used to assess the feasibility of increasing beef breeding operations in the area.

(5) Quantification of output in terms of selling weights of the various classes at different ages.

Closely allied to the above measures and also objectives of the investigation were measures of calf crop, culling rates, replacement rates, death loss, and various practices of a managerial nature such as breeding dates and practices concerning heifer replacements.

A final and minor objective was to attempt further description of the relationships involved through regression analysis which may indicate areas of resource imbalance and possible economies of scale.

HYPOTHESES

A logical step in solving the problem and meeting the objectives of the study was to formulate theoretical solutions which included visualizing the relationships that existed in beef breeding enterprises in the Peace River area. Outlining the supposed relationships gave direction to the collection of data and largely specified the testing procedure to be used.

In general, the production of beef in the Peace River area followed a pattern similar to production elsewhere in north temperate climates -- a pattern based on summer grazing, winter roughage feeding, and spring calving. Here interest was centered around obtaining information on shelter requirements, length of winter feeding, and performance characteristics such as percent of calf crop and selling weights of cattle. Such measures could then be compared with information available for beef production in other parts of Alberta.

The major objective was defining as accurately as possible, given available research resources, those input-output relationships involved in the Peace River area. A frequent observation was that input-output relationships often vary as the size of an operation increases. Of primary interest then was the major null hypothesis that small breeding herd operators do not organize resources differently than do large operators. Do managers of large beef breeding herds, who on the average receive a large proportion of their income from beef production, take

a greater interest in the enterprise, and operate more efficiently? A common belief existed that large operators were generally the best and most efficient managers since they possessed skills that have enabled them to gain control of a large producing unit.

The production process specified a functional relationship even though all the factors entering into it may not be know; or if known, cannot always be satisfactorily quantified. The general functional relationship was hypothesized to take the form that production of beef was dependent upon inputs of land, labour, capital, and management. Producers engaged in commercial beef operations were motivated to allocate their scarce resources in line with factor productivities and relative factor costs. Different factor productivities, different resource costs, and the imperfections in operator knowledge gave rise to varying quantities of resource use in beef production. The range of productive inputs observed permitted examination of quantitative relationships between factors for beef enterprises of different size.[5]

If analysis of input factor proportions indicated differences attributable to stratification by size of enterprise, then beef operations in the Peace River area may exhibit more than one functional relationship. Specification of these differences, if they exist, would be desirable so that the efficiency of small and large operations could be predicted. Farmers considering setting up a beef breeding enterprise

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[5] Problems relating to measurement and quality considerations of productive factors are to be discussed later.

could be informed of the possibilities that exist for differing scales of operation. Here the assumption was made that an operation which was planned to fall within a certain stratum would as a rule not deviate greatly from the performance of others in that stratum.

Farmers were thought to be operating with imperfect knowledge in terms of resource allocation; therefore, when factor costs were considered some degree of resource imbalance would be present. Hopefully specification of the functional relationships would identify some areas of resource imbalance. Other possible areas of resource imbalance were examined through comparison with feeding standards.

Workers engaged in this type of research have used power functions of the single equation type most extensively, fitting them to the data by least-square techniques. On the basis of their experience initial exploration of the relationships involved were proposed using the following variables:

1. Dependent Variables.
    a. Quantity of beef produced per farm over a one year period.
    b. Value of beef produced per farm over a one year period.
2. Independent Variables.
    a. Number of cows.
    b. Quantity of total digestible nutrients (TDN) used in the form of roughage and pasture.
    c. Quantity of TDN used in the form of concentrates.

d. Quantity of labour used in the beef enterprise.

e. Square feet of animal shelter.

f. Value of livestock equipment and improvement services utilized each year.

g. Variable costs (value of miscellaneous inputs used).

The coefficients derived in the relationships hypothesized above were tested statistically and against production logic.

Although the regression technique was employed, the major part of the analysis used descriptive statistics for satisfying the objectives as given on page 5 and was concerned with tabulating data on largely disaggregated input and output variables. The hypothesis that size differences do not lead to differences in resource organization will be tested by searching for differences between strata means.

REVIEW OF LITERATURE

To date published farm surveys in Alberta have concentrated on input-output relationships in value rather than in physical terms.

Current data of this type was available through "Alberta Farm Business Reports" and "Dairy Farm Cost Studies."[6] Emphasis in these reports was on the analysis of income variation between farms. While some physical data was reported on individual enterprise classifications most of it was aggregated under value terms and, therefore, remains unidentified. The usefulness of such reports could be extended by the inclusion of supplementary information on physical data. Peterson and Bauer pointed out that the detail required for the calculation of many livestock efficiency measures was beyond the present scope of their work.[7]

The Federal Farm Economics Division issues publications periodically on analyses made on farm and ranch businesses in various parts of Canada. These take the form of Spence's 1949 report on farm

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[6] These reports are being published regularly. For example see Peterson, T.A. and Bauer, L. Alberta Farm Business Report of 54 Farms in the Peace River Region. Farm Econ. Br. Alta. Dept. Agr. Multilithed report. 1962. See also McBain, B.J. Dairy Farm Business Summary. Farm Econ. Br. Alta. Dept. Agr. Multilithed report. 1962-63.

[7] Peterson and Bauer, P. 21

businesses in central Alberta[8] and the 1946 report "Cattle Ranching in Western Canada."[9] The latter is at present the major published source of physical input-output data on beef breeding herds under western conditions. The study was carried out over a three year period, 1938-1941, thereby largely overcoming the danger of selecting atypical year. In addition to measures of calf crop, winter feeding periods, death losses, roughage consumption, and carry over, the usefulness of the study was extended by outlining other production practices including such items as breeding and grazing practices. The main emphasis, however, was on value relationships. The publication did not cover the Peace River area. Beef herds in the Peace River area with few exceptions were secondary to the cropping enterprise. Vrooman _et al_. were not concerned with farm herds and surveyed the areas in Alberta where land was largely unsuited to cultivation, and cows obtained a portion of their yearly roughage requirements through winter grazing. Though out of date, the publication has remained an excellent example of ranch farm analysis covering different regions.

Another ranch study which may bear some geographical relationship

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[8] Spence, C.C. Farm Business in Central Alberta 1943-1944. Markt. Serv. Econ. Div. Can. Dept. Agr. Publ. 823, Bul. 73. 1949.

[9] Vrooman, C.W., Chattaway, G.D., and Stewart, Andrew. Cattle Ranching in Western Canada. Markt. Serv. Econ. Div. Can. Dept. Agr. Publ. 778, Tech. Bul. 55. 1946.

to the area being considered was conducted in British Columbia by Acton and Woodward.[10] However, the sample was selected from the interior valleys while the Peace River area lies to the east of the mountains. The study was patterned after that of Vrooman _et al_. but was of much smaller scope and contained only limited physical data.

Experimental results published by the University of Alberta and the various Federal experiment stations were a further source of physical data applicable to farm livestock budgeting problems. Feeding experiments were common and offered valuable guides to expected performance when using different combinations of feed inputs. However valuable the data may be, performance was not measured under actual commercial farm conditions. In addition, not all the relevant inputs were measured. Experimental data was collected under conditions of excellent management, perhaps ideal housing, adequate labour, sufficient capital (at least for the number of units in the experiment), and lack of interaction with other farm enterprises. In contrast farm conditions may be far from ideal where the family and the different farm enterprises have to compete for limited resources such as capital and labour. The data that could be furnished by experiment stations on their labour and equipment inputs would, for the reasons suggested, be

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[10] Acton, B.K. and Woodward, E.D. Cattle Ranching in the Interior of British Columbia 1958-1959. Econ. Div. Can. Dept. Agr. Multilithed report. 1961.

unsuitable for application to farm conditions unless the farms to which the data was to be applied were generously endowed with capital, labour, and management resources. The data collected on feed inputs had wider application for budgeting, but actual farm surveys were required to estimate what performance can be expected under commercial farm conditions.

On the whole, information that can be applied to farm planning using budget techniques for Alberta conditions, especially beef breeding herds, was sparse. One must turn to studies elsewhere in North America for examples of the type of data collection required and its uses.

Pond and Hasbargen working in Minnesota have collected input-output data of a type suitable for use in farm planning by searching existing studies and initiating additional surveys to fill in information gaps.[11] These studies were "...designed to determine labour, power and machinery inputs and possibly some other factors by size of enterprise, systems of management, building layout, equipment used, practices followed and similar factors."[12] For an example of the use to which such information can be put by the farmer to better organize his business see Love *et al*.[13]

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[11] Pond, G.A. and Hasbargen, P.R. Progress Report on N.C. 28 Regional Project. Univ. of Minn. Multilithed report. (*Circa* 1957).

[12] *Ibid.*, P. 1.

[13] Love, H.C., Coolidge, J.H., and McKinney, R.D. More Money from Your Farm. Kansas State College. (Manhattan) Agr. Ext. Serv. Circ. 244. 1956.

Their circular contained input-output information applicable to Kansas conditions for fifteen livestock enterprises and additional information to enable the farmer to complete his own budgets on cropping enterprises. The preparation of partial budgets made it possible for a complete farm and family budget to be completed.

Love and Heady[14] made more sophisticated use of such information in a farm organization study using linear programming techniques for Southern Iowa farms. The latter two references provided examples of the detailed types of information required by a researcher planning to assemble data suitable for use with budgeting techniques.

A number of other publications were consulted that deal with the organization and management of beef breeding herds.[15]

The secondary objective of this study was to examine a few aspects of the data with regression techniques. To date Western Canadian farm firms have been almost untouched by such analysis.

The most recent study of this type was reported by Darcovich in

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[14] Love, Harold C. and Heady, Earl O. An Analysis of Income Possibilities from Farm Adjustments in Southern Iowa. Iowa State University, Agr. and Home Econ. Expt. Stn. Res. Bul. 481. 1960.

[15] For example see Gray, James R. Southwestern Cattle Ranches: Organization, Costs, Returns. New Mexico A and M College, Agr. Expt. Stn. Bul. 403. 1956. Also bibliography numbers 15, 16, 46, 29, 40, 70.

1958 for mixed livestock-crop farms in the Olds-Carstairs area, foothills ranches, and Lethbridge area cattle feedlots.[16] Darcovich reported only the results of the productivity analysis and included none of the physical input-output data, although physical data was collected in order that prices could be applied.

Productivity comparisons were made between three aggregated input variables, land in acres, labour in months, and capital in dollars on the mixed farms and cattle ranches. Output was measured in dollars with both inputs and outputs referring to the over-all farm enterprise. Comparison of marginal return to opportunity cost ratios on the mixed farms showed no ratio less than one. Consequently, the general conclusion was that little opportunity existed for attaining equilibrium for resource use through substitution between resources. Hence profitability could only be increased by adding land, labour, and a little capital in that order.

For the cattle ranches, comparison of marginal return to opportunity cost ratios indicated that too much land and too little labour and captial were being used. Consequently, labour and capital could be substituted for land <u>or</u> more labour and capital services applied to the existing land. In terms of policy considerations the

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[16] Darcovich, W. The Use of Production Functions in the Study of Resource Productivity in some Beef Producing Areas of Alberta. Economic Annalist 28:85-93. 1958.

analysis implied that priority should be given to cattle ranches for labour and capital as opposed to the mixed farms.[17]

A study by Gilchrist of Irrigated farms in the Brooks area stratified a farm sample, homogeneous with respect to soil type, weather, topography, and cultural methods, into (1) cash crop farms and (2) livestock farms.[18] While mainly concerned with describing methodology and interpretation of results when using production function analysis, Gilchrist found cash crop farms would likely benefit by intensifying their operations on their fixed land input. In contrast he found the livestock farms could profitably employ more land and more livestock with the same quantity of other inputs. The complete farm enterprise was examined with output being measured in dollars. Five input categories were used, namely, land in acres, labour in hours, machinery, buildings, and livestock all in dollars.

The only other study believed to be carried out on Western Canadian farms was that of Harries who worked with a large sample of

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[17] The subject of this thesis applied only to a single enterprise, the beef-breeding herd within the over-all farm enterprise, therefore, productivity comparison could only be made within this enterprise for the group of farms examined.

[18] Gilchrist, Varge. The Use of The Production-Function Analysis in Studies in Farm Organization. Unpublished M.Sc. Thesis. Edmonton, Alberta, University of Alberta Library. 1952.

Saskatchewan wheat farms.[19] The complete farm enterprise was considered using as input variables -- real estate investment, livestock investment (small), machinery investment, months of labour, and cash expenses.

Though the use in Western Canada of production function analysis for farm management research has been limited, numerous studies have been made in the United States. Heady and Dillon compiled a text published in 1961 which summarized much of what is presently known on the concepts, principles, and methodology of production function research.[20] It eases the burden of the researcher planning to employ the tool since much of the information provided was previously available only in scattered sources. Summaries of a selection of production function studies that were grouped as to type of problem studied were included. Of special interest for the present problem was Chapter 16, "Functions for Fixed Plants and other Farm Situations." Therein sampling and aggregation methods with results are presented for several studies.[21]

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[19] Harries, H.W., Production Functions and Short Run Cost Curves within the Wheat Firm. Unpublished Thesis. Ames, Iowa, Iowa State College Library. 1946. (Original not available for examination; reviewed in Gilchrist, op. cit., pp. 42-44.

[20] Heady, Earl O. and Dillon, John L. Agricultural Production Functions. Ames, Iowa, Iowa State University Press. 1961.

[21] Ibid., pp. 554-584.

A short review follows of some aspects of those studies pertaining to the development of functions for livestock enterprises. All the studies reviewed used the Cobb-Douglas function.

Heady completed a study in 1945 which used as variables:

> Y, the value of livestock products produced (dependent variable);
> L, the input of labour, in dollars, on livestock;
> S, the input of livestock capital services in dollars.
> It includes as annual inputs of livestock: The beginning inventory value of chickens, fattening pigs and cattle plus depreciation computed for milk cows, brood sows and laying hens. Closing inventory of growing and fattening stock were used as an output, while beginning inventory figures were used as an input. Also included as inputs were the value of all grain, hay, pasture, supplemental feeds, building equipment, and machine services used on livestock. For buildings and machines, depreciation and repairs were used as inputs.[22]

In this study it was necessary to aggregate the inputs of livestock feed and building services because they were found to be highly correlated. Farmers tend to think of these inputs as being technical complements and hence increase their quantities together.[23]

The derivation of the crop function in Heady's study illustrated an important point. The 70 farms selected were all 160 acre farms on

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22 Heady, Earl O. Productivity and Income of Labour and Capital on Marshall Silt Loam Farms in Relation to Conservation Farming. Iowa State College. Agr. Expt. Stn. Bul. 401. 1953. In Heady and Dillon, op. cit. pp. 555-558.

23 Ibid., p. 557.

one soil type. The sample was therefore stratified to make the land input on each farm a constant as far as possible. This procedure enabled the land input to be eliminated from the crop function.

The crop function was then given in which:

> Y is the value of crops produced;
> L is labour measured in dollars used on crops;
> M is machine services used for crops;
> C is crop services of seeds, insecticides, and other supplies;
> F is input of fertilizer, lime, and manure-all measured in dollars.[24]

A later study conducted by Brown and Heady incorporated two more independent variables into the livestock function.[25] Regarding the value of inputs and outputs of the livestock, the data was handled as in the previous study. The function used as variables:

> Y, denoting gross income from livestock which includes the values of nonbreeding stock on hand at the end of the year plus all livestock products sold or used on the farms;
> Z_1 denoting value of all feed fed during the year;
> Z_2 denoting the labour used for livestock production;
> Z_3 denoting the number of square feet of building space used for livestock production;
> Z_4 denoting the dollar value of miscellaneous livestock services which includes values of nonbreeding stock on hand at the beginning of the year or purchased during the year; breeding stock depreciation; livestock machinery depreciation, repairs and operating expenses; livestock supplies and mechanical expenses; livestock commissions; and electricity and telephone charges.[26]

The equation developed from the data resulted in marginal value products as follows: for feed \$ .32 per dollar of input; for labour

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[24] Ibid., p. 556.

[25] A study by Brown, David W. and Heady, Earl O. reported by Brown, David W. Adjustment of Value Productivity Estimates to Changes in Price and Technical Relationships. Unpublished Ph.D. Thesis. Ames, Iowa, Iowa State College Library. 1956. In Heady and Dillon, op. cit., pp. 564-568.

[26] Ibid., p. 566

$21.02 per day of input; for building space $ .015 per square foot; for livestock capital services $1.43 per dollar of input. A problem of multicollinearity existed between feed and livestock capital there being a correlation coefficient of .91. Therefore, these two inputs were aggregated, and a new equation developed. The change resulted in the marginal value product of the new aggregate being $1.13 while the MVP of labour changed to $18.34 per day. The result of further aggregation means that an estimate of MVP for feed and the separate livestock capital inputs were no longer available. The high correlation between these variables cast doubt on the reliability of the coefficients originally developed.

The input categories of one further study as reported in Heady and Dillon was of importance to the problem under consideration. It concerned development of functions for a laying hen enterprise in which size of enterprise is included as a separate and explicit variable.[27] The equation used variables in which:

Y is the number of eggs produced (dependent variable);
X_1 is the number of hens;
X_2 is square feet of housing;
X_3 is hours of labour;
X_4 is pounds of corn equivalent;
X_5 is pounds of 26 percent protein equivalent.[28]

This equation would suggest that a possibility existed for using number of animal units for a beef enterprise rather than inputs of livestock in value terms as was done in the equations in the studies reviewed.

The foregoing brief review of some production function studies revealed those that have been carried out locally and a number of those

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27 <u>Ibid</u>., pp. 568-573.

28 <u>Ibid</u>., p. 569.

that are of special interest to this study because they suggest aggregation procedures for variable selection that might be suitable for a beef breeding enterprise. This study was concerned only with application of multiple regression to what was hoped would be an amenable set of data. The more important aspects of regression analysis regarding use, suitability, and interpretation will be presented in the discussion concerning statistical techniques and results.

PROCEDURE

Required Information

In order to satisfy the stated objectives and to test the hypotheses, one must specify the data required; then appropriate procedures for obtaining the information can be sought. The physical resource requirements for raising beef calves and yearlings can be broadly categorized under land, labour, and capital. Management as a non-physical, intangible organizing factor was included only to the extent that certain practices concerning the organization of the previous factors suggested some level of management skill. Since the beef enterprise was under examination, the three measurable resources engaged in beef production only needed to be collected. Two problems arise -- defining the appropriate inputs and separation of inputs usable for several enterprises. Examination of linear programming and budgeting studies indicated what are considered to be the relevant inputs for beef production.[29]

Defining output did not present the same problems.

Feed (land) inputs One approach commonly used for the land input on mixed livestock-crop farms was to measure the kinds and quantities of feed inputs used. Because of the similarity of practices in an area -- a result of climate and market conditions -- feed inputs for a given class of stock tend to be uniform. Land inputs -- measured by acres -- varied widely for a given level of feed production. Land quality in the Peace River area was highly variable, thus the study

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29 See for instance: Love and Heady, op.cit., table A-11. p. 839. Love, Coolidge and McKinney, op. cit. p. 90. Prater, Tom E. and Maddox, L. A. Guide for Estimating Annual Return to Labor Management and Capital, Cow-Calf Operation. Texas Agr. Ext. Serv. Publ. MP-398. 1959.

concentrated on measuring feed inputs.[30]

Required data includes the kinds and quantities of feed fed to various classes of beef stock and information on the time periods in which preserved feed and pasture were made available to each class. Inputs of bedding had to be included. For this class of resources as well as for labour and capital all data of necessity covered a size range of beef enterprises to permit testing for differences between size strata.

Labour inputs To define and quantify the labour resource entering into beef production involved few conceptual or practical problems compared with those encountered in defining capital inputs. Nevertheless, decisions had to be made as to the labour inputs to be charged against the beef enterprise. For example, was haying labour a part of the crop or the beef enterprise? If a cash market for hay existed, haying labour would appear to be part of the cropping enterprise, and the hay used for livestock would be charged against beef at some dollar value. If one decided, as was the policy of this study, to report as many inputs as possible in physical terms, haying labour in hours would have been charged against beef; the remaining inputs would have continued to be measured in value terms. If haying labour were included, then labour in seeding and hay land preparation also might have been included, and one would not have known where to

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30 Some effort was made to collect land inputs directly, and a number of averages were reported. These were of limited usefulness, and farm planners using the data for specified farms will be required to estimate the quantity of land needed for feed production and pasturage.

stop.[31] The researcher must decide arbitrarily on those inputs to be included.

In the Peace River area there was a complementary relationship between hay and grain crops coupled with a lack of a reliable market for hay.[32] The cost of hay to the beef enterprise can be assumed to include only the cost of hay harvest since forage would be grown anyway for its contribution to following grain crops. Accordingly, only the labour necessary to harvest and store the hay had been added to the labour charged against the beef enterprise.

Other labour inputs were attributed directly to beef production. These included labour for winter feeding, inspection, buying and selling, handling, and maintenance of livestock equipment. Various indirect labour items that do not lend themselves to exact definition were excluded. These included items that contributed to the operation of the farm as a whole but could not be identified with any one enterprise. Examples of such items were: the time spent on bookkeeping, various fire control precautions, general pest control measures, and telephone line repair.

Common to such studies no allowance was made for difference in labour quality between farms.

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[31] The argument can be carried to extremes when one considered that labour was mixed with many capital items purchased by the farm as inputs, part of which eventually find their way into beef production.

[32] During the interview a number of operators when questioned on the value that they attached to their hay inputs stated "We have to grow hay", meaning that cropping conditions were unsatisfactory if forage was not included as part of the rotation.

Capital inputs   For the capital inputs involved in beef production, specification created a lesser problem than did separation since the same input was often spread over several enterprises. Yet there were many capital inputs largely attributable to the beef enterprise. These included corrals, troughs, chutes, fences, veterinary tools and supplies. That part of barn or shed space involved with the beef enterprise must be measured along with a portion of the watering system and various machine inputs like tractor, truck, and auto. The decision was made not to collect expense data on machine inputs used in the beef enterprise in order to shorten a long questionnaire and to devote the greatest attention to collection of data of which little or nothing is known. The judgment was that "office estimation" of machine expenses (small in proportion to total expenses) would not result in serious error because information was at hand on individual farms concerning the type of haying equipment used, amount of forage put up, tons of ground grain used, time and type of equipment used for manure removal, and distances to town and summer pasture.[33] The estimation of machine expenses for the beef enterprise involved arbitrary decisions on procedures when general use machines such as trucks and tractors were involved.[34]

As with labour a portion of those capital input items that contributed to the farm operation as a whole (say legal fees) were not allocated to the beef enterprise.

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[33] Expenses on equipment for hay or silage preparation have not been estimated in this study since it was felt that specific knowledge of the area was not required to arrive at reasonable estimates.

[34] See page 40 for estimation procedure.

A further group of purchased inputs can be stated in physical terms. Included were salt, mineral, protein supplements, and vitamin A.

Output Data on calf-crop, death loss, culling rate, replacement rate, and bull replacement procedures comprise important information needed by the budget analyst to calculate the quantity and quality of beef that could be made available for sale. Also required were estimates of the expected weights to be attained by the various ages and classes of stock. To attempt estimation of a production function and various measures of performance, data was required on sales, purchases, home use, deaths, opening and closing inventories (over a one year period), and weights of all classes of beef animals involved on any one farm. Respondents were not asked to give weight estimates of their animals on opening and closing inventory dates.[35] For statistical techniques see Appendix F.

Management practices Though it was not strictly required for describing input-output relationships, additional information on certain practices and procedures engaged in by beef operators in the area was collected to enhance understanding of the production process.

Statistical Techniques

Once obtained, the above data was stratified by size of beef operations and organized to permit examination of relationships. The data were examined with the aid of descriptive statistics by use of the arithmetic mean, mode, range, standard deviation, standard error of the mean, and coefficient of variation. Details of the statistical procedure are presented in Appendix F.

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[35] See pages 41-42 for estimation procedure.

ANALYSIS OF THE DATA

Problems with Original Stratification

Number of breeding cows at time of interview (July 31, 1963) was the variable used for the original stratification presented on preceding pages and the one on which subsequent analysis was to be based. Initial inspection of the data revealed this to be an unsatisfactory measure of size for the following reasons.

(1) Only seven of the 45 operators interviewed were on a cow-calf basis where the calves were sold November first or immediately thereafter. Therefore, the majority of operators were engaged both in breeding and feeding enterprises.[36] Separation of inputs (with the exception of feed) between feeders and breeding herd was impractical.

(2) The operator may have just "sold down" or "bought in" with either (or both) feeders and breeding animals with the result that inputs expended on any one farm may bear little relationship to number of breeding cows at interview time.

(3) Any one operator because of his replacement and/or culling procedure and whether or not yearling heifers were bred would have a breeding herd differing in makeup from that of another operator resulting in distortion when comparing inputs between farms.

(4) A number of operators would retain and breed as yearlings all the previous summer's crop of heifer calves and sell a portion of them as bred heifers in the fall. In this study heifers treated in this manner were not considered to form part of the breeding herd.

<u>Restratification</u> To make intra-farm comparisons more meaningful,

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[36] See section immediately following for definitions.

a weighing procedure was adopted which took into account variation in livestock class mix and time variation. While no completely satisfactory method was devised, conversion to "animal units" based on body size and feed consumption was used.[37] Arraying enterprises by animal units suggested that the use of four strata rather than three would be preferable for testing for differences between strata despite the loss of degrees of freedom.

Within any stratum based only on number of breeding cows wide variation occured in the proportion of feeder animal units to total animal units (feeders and breeding herd combined). To better consider the effect of this important source of heterogeneity, the sample was arrayed according to the variable "percent feeder animal units/total animal units x 100" which in turn suggested a division into three strata. When this variable is small, less than ten percent, the operation could be said to be primarily a cow-calf operation. As calves are kept for longer periods past November first or feeders purchased, the variable increases.[38]

One would expect to find significant differences between input-output relationships for the operations stratified according to percent feeders even though the weighing procedure for the different animal classes is designed to mask these, at least for the feed inputs. Tests of significance between feeder strata were made.

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[37] See the following section for definition and discussion.

[38] Characteristics of the stratifications used are given on pages 50 and 51.

Definitions

Breeding herd   The breeding herd included those animals involved in practices that were part of a beef breeding enterprise producing only calves for sale at November first plus a normal complement of replacements.[39] Any animals involved in other enterprises were placed in the "feeder" category. As in the previous section an operator making a practice of selling bred heifers at 18 months of age would have such heifers counted as feeders and not as a part of the breeding herd. The few breeding heifers that might have been culled and sold at 18 months of age because of unsatisfactory characteristics were considered part of the breeding herd.

Feeders   The feeder category included the residual of animals not defined as part of the breeding herd. Breeding animals being produced for sale as breeding animals were defined as feeders for this study. Older cows purchased in the fall and sold off before spring were counted as feeders. On November first heifer calves were defined as replacements (breeding herd) or as feeders depending on their planned use.

Average animal units per year   Many different weighting factors, most of which would appear to be in need of examination and revision, are in use for the different classes of stock.[40] Since weighting factors are at best a compromise and in order to retain comparability between studies, the weighting factors of McNarry *et al*. were used.[41]

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[39] In most cases November first was the date of weaning.

[40] For a discussion of the problems, see Appendix B.

[41] McNary, W.L., Price, R.D. and Peterson, T.A., Central Alberta Farm Business Association Farm Management Analysis Report. Farm Econ. Br. Alta. Dept. Agr. Multilithed report. 1962, p. 14. See also Acton and Woodward, *op. cit.*, p. 43.

1	cow (and calf if under 6 months)	=	1 A.U.
1.5	heifers between 1 and 2 years	=	1 A.U.
1.5	steers between 1 and 2 years	=	1 A.U.
1	steer over 2 years	=	1 A.U.
3	calves under 1 year	=	1 A.U.
1	bull over 2 years	=	1 A.U.

The age of the stock was calculated using as birth date the date at which the operator estimated the majority of calves were born. The number of animal units on each farm was computed by the following method: (number in age group classification) x (number of months on farm) x (percent of 1.0 animal unit) x 0.0835 (the decimal form of 1/12). The portion of 1.0 animal unit used for each age group was .33 for calves up to weaning, .67 for yearlings, 1.00 for two year olds and over, and 1.40 for mature bulls. A sample calculation of average animal units per year for five calves less than twelve months old kept for three and a half months would be: (5 calves) x (3.5 months) x (0.33 A.U.) x (0.0835 years) = 0.49 average animal units per year. If kept longer, they would be weighted by the factor 0.67 as they became yearlings. All such groupings of animals were added to determine the average animals units per year.[42]

<u>Breeding herd animal units and feeder animal units</u>
Animal units were calculated as defined above and placed into categories defined by breeding herd and feeder classifications.

<u>Death loss percentage</u> This measure was calculated using as numerator the number of animals missing or died past weaning age with the exception of those which the operator was confident had been stolen.

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42 Hereafter to be called "animal units" and abbreviated to "A.U.'s". Another measure "grazing animals units" was devised. See following section for definition.

The denominator used was animal units.

Cow/bull ratio This measure was computed by using the number of breeding females on hand at time of interview.

Calf crop Numerous methods have been used for calculating calf crop. Vrooman et. al. used calves at branding time as a percentage of all cows and yearling heifers in the breeding pasture the previous summer.[43] This study computed calf crop as a percentage of the number of cows kept because the operator expects a calf. This definition suffered from lack of objectivity, but since many operators sell off their cull cows in the fall, a computation which uses as denominator all those females on summer pasture will underestimate calf crop. (Figure 1 illustrates the problem.)

	Winter			Spring and Summer
12	yearlings		76	nursing calves
12	2-year-olds		10	dry or old and will sell in Fall
64	mature cows	2 die		
88	expect to calve		12	breeding yearlings
12	replacement calves		98	females in breeding pasture
100	females			

Fall and Winter

88	expect to calve
12	replacement calves
100	females

Calf crop = 76/88 or 86 percent

Figure 1. Hypothetical seasonal variation in numbers and ages of breeding stock when breeding herd is kept constant at 100 and replacement rate is 12%, with yearling heifers bred.

In reality cull cows may be sold anytime. The number of cows kept after the middle of December was used as a rule to calculate calf crop, unless

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43 Vrooman et.al., p. 59.

it was obvious that certain cows were being kept as feeders. In some cases operators sold cull cows in mid-winter or whenever they discovered a cow would not calve. Respondents' answers to certain questions enabled estimation of the number expected to calve.

Replacement rate Obtaining an estimate of replacement rate (and culling rate) was difficult owing to increasing and decreasing herd size and consequent variation in age composition of any given herd. Most operators interviewed were increasing the number of cows in their herds in some cases as rapidly as possible without buying heifers. Therefore, these operators had a low culling rate compared to their replacement rate and as long as increase continued the culling rate would lag. Those who were increasing herd size less rapidly or not at all retained more replacement heifers than desired and culled a number after their first calf. Also a number of operators had not been in the business long enough to require culling. Thus a number of different replacement rates are reported.

Initial replacement rate Operators were asked to estimate the number of replacement heifers they would hold back if their operation was in a stable situation. The initial replacement rate reported indicated the number of heifer calves that would be held back and bred. The number of females of breeding age at time of interview was used as denominator.

Final replacement rate This figure differed from initial replacement rate if the operator culled a number of yearling heifers for poor performance. The number of heifers finally retained was

expressed as a percentage of the number of breeding females. In reality retaining more heifers than desired to finally include in the herd can be expressed as a higher replacement rate and a consequent higher culling rate. However, in reporting culling rates operators tended to think in terms of culling the older age groups.

Actual replacement rate Each record was examined for the actual number of replacements that had been placed in the herd compared to the total numbers being bred for the two inventory dates -- July 31, 1962, and July 31, 1963. The two figures obtained were averaged and reported as actual replacement rate. Because most operations were increasing in size, the number saved for replacement was larger than it would be if size stability had been reached.

Culling rate As with questions on replacement rates question 20 (Appendix A) was modified in the field to obtain the operator's estimate of culling rate in a stable situation. The two percent death loss indicated in Figure 1 may decrease the number of cull animals sold -- unfortunately death losses do not always occur among the culls.

Tabulation of Feed Inputs

Preserved roughage

The majority of operators were able to estimate the total roughage available of different kinds for both feed and bedding at the beginning of winter and the amounts remaining at the end of the winter feeding period. Minor adjustments were made for roughage sales and purchases, for the few milk cows, and some horses involved.[44] Detailed information

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[44] Horse inputs pertaining to the beef enterprise were converted to value terms and included in miscellaneous expenses enabling feed inputs to be associated with beef production only since feed to horses goes for power and may contribute to beef output only indirectly.

was collected on the division of roughage among livestock classes. Usually agreement between total quantities and the summation of quantities fed to the livestock classes was judged to be reasonable. Agreement of totals was forced by making proportional adjustments to farmer estimates of quantities going to classes.[45] Where initial agreement was low -- less than 20 percent -- apportioning feed to livestock classes was not attempted.

Roughage used for bedding was separated and reported even though the procedure was open to question. Roughage was presented to animals and what was not eaten was used for bedding. Spoiled roughage lavishly provided resulted in much being used for bedding. Extreme variation occurred among operators in quantities of bedding used. Reporting only total roughage used with the bedding component hidden would provide little information on roughage consumed as feed on those farms that used much bedding. Disaggregation was preferable because many operators provided information on bedding used.

A major departure from normal practices by five operators -- making straw or chaff piles or straw stacks available to cows for part of fall and winter -- required that their cow roughage consumption figures aside from straw piles be reported separately. For regression analysis separate estimates of bedding and feed inputs obtained from straw piles were made for these operators to retain sample size. For regression purposes all roughage feed inputs were aggregated under total digestible nutrients (TDN) using Morrison's coefficients.[46]

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[45] See Hopkins, John A. and Heady, Earl O., Farm Records and Accounting. 5th ed. Ames, Iowa, Iowa State University Press. 1962, p. 35.

[46] Morrison, Frank B., Feeds and Feeding. 22nd ed. Ithaca, N.Y., The Morrison Publishing Co. 1956.

Grain

For grain inputs no cross check was available as for roughage. Operators supplied information on kind, proportion, preparation, and quantities of grain fed each class at different periods. Appendix C gives the weights used for volume measures.

For regression analysis all grain inputs were aggregated under TDN using Morrison's coefficients.

Protein supplement

Information was collected on the various brands of feed supplements. Component ingredients were separated as accurately as possible and reported separately. The average analysis of protein supplements reported was 37 percent digestible protein and 75 percent TDN.

When preparing data for regression analysis, protein was weighted because it contributed more to beef production than its value of TDN suggests. Thus each farm using protein supplement was examined, and a weighting factor ranging from 2.7 to 5.3 was applied to each pound of TDN in protein supplement fed. Empirical evidence was available to suggest that substitution ratios between TDN in grain and TDN in protein supplement were within this range for the proportions of hay, grain and protein supplement fed by Peace River area operators.[47]

Pasture inputs

Pasture inputs in TDN were estimated so that all inputs of feed would be included for regression analysis.

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[47] Heady and Dillon, op. cit., pp. 462-465. See especially equation 13:11 p. 463. Concentrates used in the Peace River area must be converted to corn equivalent for use in equation 13:11 and the MRS calculated reconverted.

Because data was collected over parts of two pasture periods, it was convenient to retain the separation with the relevant date being July 31, 1962.[48] The pasture period, April to July 31, is that of heavy milk flow when calves are almost wholly dependent upon their mothers. National Research Council (NRC) data on TDN requirements for cows nursing calves were used.[49] Dry cows were given a TDN allowance somewhat above NRC recommendations for wintering mature pregnant cows since weight gain in most cases could be expected for dry cows on spring grass. Nursing heifers were treated similarly to cows in the first pasture period.

In the pasture period August first to winter feeding, calves and nursing cows were separated for TDN computation. Cows were treated as if on maintenance and in most cases were allowed slightly more than eight pounds TDN per 1,000 pounds live weight to allow for some weight gain at this time of the year. This procedure eliminates the need to adjust for dry cows. The nutrients transferred to calves by their mothers during this period along with those of the calves' grazing activities were estimated using the equation

$$TDN = 0.03725\ W^{.75}\ (1 + 0.59g)$$

where TDN is pounds required daily; W is the weight of the animal in pounds and g is daily gain in pounds.[50] Animal weight and gain figures

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48 Working with a calendar year would have presented considerable difficulty with defining winter feed inputs and additional problems with partly finished feeder class inventories.

49 Nutrient Requirements of Beef Cattle. National Academy of Sciences, National Research Council, Washington, D.C. Pub. 1137. 1963. pp. 1-8.

50 Ibid., p. 3. The equation used by NRC was divided by 2,000 to convert to TDN. Note that NRC used this equation for most of its energy and TDN recommendations.

for use in the equation and NRC tables were estimated from sale weight data and farmer estimates of mature cow weights at the beginning and close of the pasture season. Yearling heifers and steers on the majority of farms did not appear to be gaining as rapidly as suggested by NRC normal growth figures hence TDN allowance for these classes on many farms was reduced below NRC figures. In this second pasture period two year old heifers were considered to be making normal growth if not nursing. If nursing, the TDN allowance was slightly greater than maintenance on the assumption that NRC requirements for wintering pregnant heifers does not allow for weight gains as large as heifers would make on pasture, considering the TDN allowance for lactation has been transferred to the calves. Bulls were credited with TDN allowances as suggested by NRC. Various published materials aided in estimating weight and gains.[51]

Salt, calcium and phosphorus supplements, vitamin A

As suggested under the subdivision "protein supplements", salt, calcium and phosphorus supplements, and vitamin A have been separated from all sources and reported separately as quantities used by the total operation.

Tabulation of Labour Inputs

Labour by operation (haying, manure removal etc.) was recorded and distributed among months according to operator's estimates of the months in which the work was performed. The beef operation was not charged haying labour for hay carried over or for hay going to milk cows or horses.

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[51] Morrision, op. cit., p. 743. Maynard, Leonard A. and Loosli, John K., Animal Nutrition. 5th ed. New York, McGraw-Hill Book Co. Inc. 1962. pp 339-347, 387-391. Also see bibliography numbers 2, 3, 9, 45, 46, 33, 48.

Tabulation of Land Inputs

Attempts to identify land inputs largely broke down in the face of numerous difficulties. Limited information was provided by the following measures.

Grazing rates

Grazing rates on native pasture and bush as one category, and on tame pasture, hay land, and forage seed crop land for the other were estimated for those operators whose pasturing practices could be followed. A typical calculation for an operator who pastured 27 acres for 83 days with 14.3 animal units would be: $27/14.3 \times 365/83 = 8.3$ acres per animal unit for one year.[52]

Cultivated land

Total acres of land in tame hay, tame pasture, and forage seed crops were reported for farms because this land was involved with livestock in one way or another. No satisfactory weighting factor for the different land use categories was devised.

Uncultivated land

Operators supplied estimates of the percentage of this land that was open or covered by bush. Only uncultivated areas used for pasture were included; proportions and totals were reported.

Cultivated land in secondary use

Land used for cereal crops was a source of (1) baled straw, (2) straw stacks for fall and winter, (3) straw and chaff piles for fall

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52 Animal units as used in grazing calculations differ from those on which the rest of the analysis is based. One animal unit (grazing) is defined as requiring 13.2 pounds TDN per day, somewhat less than NRC requirements for a nursing cow 3-4 months post-partum. See Appendix B.

and winter, and (4) fall grazing. Acres of cereal crops for these uses were estimated in the following way. Nearly all operators baled straw hence acres for categories two and three were estimated as though the cereal by-products were actually baled. A generous allowance for bedding was made for the five operators using straw piles and stacks. Only eleven operators provided sufficient information to estimate straw yields. Their average yield was 0.6 tons per acre, and this coefficient was used to estimate acres of straw utilized by beef. A number of the following: animal units (grazing), days, and acres were available for strata four. Since 29 days was the average time stock was on stubble, comparisons were made on the basis of acres per animal unit for a month (31 days).

Buildings, Equipment, and Miscellaneous Inputs

Depreciation on buildings and livestock equipment was based on farmer estimates of the length of service to be expected from these capital assets. The annual value or cost of improvement services from sheds, barns, fences, and corrals was the cash cost of repair for up-keep plus insurance premiums and the annual allowance for depreciation. Native materials were readily available and could be secured and erected with operator labour and small outlays of fuel and repairs on general purpose farm machines and tools. If labour was hired specifically to secure and erect native material, these costs were included. If commercial lumber was purchased, it was included. The procedure adopted was designed to estimate the cash costs experienced by operators in providing equipment for the beef operation in the expectation that new operators could become equipped for a similar cash outlay. Dugouts, veterinary tools, and other small tools were treated as a sunk cost, no

depreciation being charged. Operator estimates of yearly repairs and replacements on buildings and equipment were reported separately. Only the proportion of barn, shed, and watering facilities applicable to the beef enterprise was reported.

Manure removal charges were applied only when the manure was not spread on the land. If spread, benefits from manure were assumed to equal costs of removal and spreading.

Other miscellaneous costs estimated included concentrate grinding and handling, use of truck or car for running errands (inspection, salting), electricity charges (pumping water, where applicable), magazines and telephone. Costs of equipment relating to roughage preparation and hauling were not considered in this study.

Tabulation of Beef Output

At the two inventory dates the average weights of animals and their values were assigned with a consideration of weights and prices received on sales and feeding practices for each farm. For breeding classes and calves identical weights were assigned for July 31/62 and July 31/63. For feeder classes adjustments were made if procedure had changed or purchased stock was involved. Growing bulls often required weight adjustments because there were differences in feeding practices.

Breeding classes were assigned identical values on the two inventory dates since this stock was not being kept for sale. Calves and other feeder stock were valued at Edmonton market prices both at inventory and sale dates.[53] Breeding animals sold for breeding purposes were

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[53] For average prices that were applied to breeding stock (good cows, good feeder heifers, etc.) see Livestock Market Review. Mkt. Div. Can. Dept. Agr. Annual Report. 1963. p. 23. For non-breeding classes see Edmonton weekly prices in Livestock and Meat Trade Report. Mkt. Div. Can. Dept. Agr. Weekly Report. July 31, 1962 - July 31, 1963. p. 10.

valued at sale prices. Bulls were valued according to operator estimates. Value or pounds of beef produced was equal to closing inventory plus sales minus opening inventory plus purchases.

Special procedures were adopted to achieve comparability when (1) all farms did not sell at the central market, (2) all beef produced was not sold (the inventory problem), and (3) all farms did not buy feeders. Since most of those interviewed sold at the central market, adjustments were made to treat those who sold locally as if they had sold centrally. By this procedure gross value of beef produced did not have hidden marketing charges for those who sold locally. One assumes that no net advantage was gained in either market. Only local marketing charges were applied to breeding animals sold. These were total marketing charges, for breeding animals generally remain in the area. Therefore, all beef produced except breeding stock, whether sold or not, had Edmonton marketing charges applied ($1.24 per hundred weight). With minor exceptions purchases were made locally. Pounds of beef purchased had local buying charges (transport mainly) applied. The same number of pounds of beef purchased had Edmonton marketing charges applied since this same beef must be resold in the future. For those operators who sold non-breeding animals locally, $0.75 per hundred weight was added to the gross price received.[54]

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[54] Comparison of operators' sales receipts revealed the $0.75 per hundredweight differential between gross prices at the local and central market which coincides with the transport rate. The result is coincidental, and no sweeping conclusions can be drawn.

RESULTS

Inportant Characteristics Relating to Beef Operations

Length of winter feeding period

Comparative data for different areas of Alberta is given in Table 1. The comparatively low level of precipitation in the Peace River area was balanced by accompanying cooler temperatures and somewhat lower wind mileages than in the other two areas.[55]

For the data on winter feeding Vrooman et al. warns that their three year data was collected during winters somewhat milder than usual (page 12). During the 20 year interval between the Vrooman report and this study, nutrition research findings may have caused cattlemen to increase the daily winter feeding levels and/or extend the feeding period.[56]

The author was unfamiliar with all circumstances concerning Canada Department of Agricultural Economics Branch questionnaire data except for the Shortgrass area data was collected on the winter 1960-61 following a summer of severe moisture limitations. Consequent lack of winter grazing may have forced operators to feed longer. In some cases herds were partially liquidated. Foothills operations did not suffer similarly.

As a rule Peace River operators have fed an average of 184 days because winter grazing was not available (see Table 2). A few operators

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[55] For extended discussions see: Alberta Farm Guide, see Table 1,a Alberta Soil Survey Reports 5, 6, 9, 10, 15, 17, 18, 20. Res.. Council Alta., Can. Dept. Agr., University of Alberta. 1941-1961.

[56] Impression obtained from private communication with L.W. McElroy, Chairman, Department of Animal Science, University of Alberta, 1964.

Table 1. Climatic and other characteristics influencing beef production in three areas of Alberta

Area	Shortgrass	Foothills	Peace River
Mean frost free period (days)[a]	100-200	40-80	80-100
Mean precipitation (inches)[a]	10-15	20-25	14-18
Soil type[a]	brown	thin blk. -black	grey-some deg. black
Carrying capacity	low-med.[b]	med-high[b]	low (bush)
Acres/cow/month[c]	3.3-4.2	2.0-2.7	5.0
Winter feeding mature animals (days)[d]	83 (130)	99 (144)	184
Winter roughage mature animals (tons)[d]	0.75(1.3)	0.82 (1.4)	2.3

[a]From Alberta Farm Guide. Univ. Alta., Can. Dept. Agr., Alta. Dept. Agr. Edmonton, Alberta. 1963. pp. 3-7.

[b]Vrooman et al., op. cit., p. 11.

[c]Range, Its Nature and Use. Lands Br. Alta. Dept. Lands and Forests, Ext. Br. Alta. Dept. Agr. Pub. 146. 1960. pp. 20-24.

[d]Open figures from Vrooman et al., op. cit., pp. 19 and 38. Figures in parentheses are the results of author's calculations using 1961 ranch questionnaires made available by the C.D.A. Econ. Br., Edmonton, Alta. Peace River data is from this study.

who enjoy a micro-climate afforded by long southward facing slopes along a major river or other land declivity can expect to feed a somewhat shorter period.

The winter roughage quantity reported (Table 1) was the sample mean. Although several operators complained of poor feed quality through spoilage, the author estimated that this quantity will be used regardless of quality. The data in Table 2 on extreme dates was based on operator experience and in some cases on the worst experience of pioneer stockmen in the area. The mean date was calculated using the extreme date submitted by each operator hence for the absolute extreme experienced the appropriate minimum or maximum date should be noted. No significant differences were found to exist between strata, indicating that operators stratified at least by size of their herd were in agreement on wintering periods.

Distance to market

Table 3 indicates that most of those sampled preferred selling in the central market. The differences in mean distances of markets for cull cows and calves and yearlings was caused by the same operators not selling both classes locally. Too, operators were more particular in choice of market for young stock and would go farther, in some cases beyond the Edmonton central market, to sell. The figure of 315 miles represented the true mean distance of operation headquarters from the Edmonton yards. No significant differences were found between size strata in their preference for either local or central market.

Table 2. Operator estimates of normal feeding periods for cows and calves and operator experience of extreme feeding dates for cows stratified by total animal units; Peace River area of Alberta

Strata (AUs)	1	2	3	4	
Animal units	0-33.5	33.6-59.5	59.6-89.5	89.6+	Pooled
Normal period (cows)					
Mean (days	189	174	185	187	184
Std. error	6.1	5.2	7.1	8.1	3.4
Range	154-223	151-196	151-230	184-250	149-250
N	11	10	11	11	43
Earliest had to feed cows (Fall)					
Mean date	Oct.15	Oct.18	Oct.14	Oct.7	Oct.13
Range	Oct.1-Oct.25	Oct.1-Nov.6	Aug.15-Nov.15	Sept.15-Nov.1	Aug.15-Nov.15
Latest had to feed cows (Spring)					
Mean date	May 21	May 10	May 22	May 20	May 18
Range	May 1-June 15	Apr.15-June 1	May 15-June 1	Apr.25-June 22	Apr.15-June 22
Latest left cows before feeding (Fall)					
Mean date	Nov.26	Dec.1	Nov.27	Nov.21	Nov.26
Range	Nov.1-Dec.25	Nov.1-Jan.4	Nov.1-Dec.25	Oct.15-Jan.6	Oct.15-Jan.6
Earliest turnout (Spring)					
Mean date	May 5	Apr.21	May 2	Apr.28	Apr.29
Range	Apr.30-May 15	Mar.28-May 15	Apr.20-May 15	Apr.5-May 15	Mar.28-May 15

Table 3. Number of operators selling to, and mean distances to, either central or local markets for cull cows, and calves and yearlings, Peace River area, 1963

	Local	Central
Number of operators selling cull cows	13	31
Mean distance (miles to market)	32	315
Number of operators selling calves and yearlings	12	32
Mean distance (miles to market)	43	340

Increasing livestock numbers in area

Operators interviewed had increased herd size on the average by 48 percent over the past three years, and at interview time 26 were planning over the next three years to increase by another seventeen percent (Table 4). Of the remaining eighteen, sixteen were planning to increase, and two were undecided.

Table 4. Percent increase in numbers of breeding females summer 1963 compared to numbers summer 1960, and planned percent increase in numbers to be bred in 1966 compared to numbers summer 1963

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (historical)	125	121	210	150**	148**
Std. error	18.8	12.7	51.6	11.7	13.7
N	11	11	9	10	41
Mean (planned)	107	94.6	148	111	117*
Std. error	4.9	5.4	17.8	18.6	7.4
N	8	5	7	6	26

*Increase significantly different from 0 at 5% level (two tailed test).

**Increase significantly different from 0 at 1% level (two tailed test).

[a]The number of animal units in each stratum is given in Table 2, page 46

The decrease in number responding when asked about future plans was noteworthy; those responding quantitatively indicated they would increase by less than the historical increase of the larger group. While this result was possibly due to farmer uncertainty, a number of operators said their beef operation was nearing a size consistent with their farm. Means were significantly different only between strata two and three with respect to planned size; this difference was largely due to sampling. No reason other than chance occurrence appears to explain the large differences between strata two and three

Distance to summer pasture

Operators were asked how far they would be willing to move to summer pasture. The results in Table 5 possibly were biased downward since a number of those operators with pasture available close at hand (three or four miles) said they would not go farther. The interviewer felt that if this convenient pasture was unavailable, many would be willing to go farther. Operators quoting the greater distances were willing to move only on condition that they would not have to provide supervision.

Table 5. Distance in miles operators would be willing to move animals in order to obtain summer grazing

Strata (AUs)[a]	1	2	3	4	Pooled
Mean	12	16	52	29	28
Range	4-33	4-50	2-100	1-80	0-100

[a]The number of animal units in each stratum is given in Table 2, page 46.

Selling procedures for young stock

Table 6 tabulates the results of question six (Appendix A). The results were an indication only as respondents often were unable to quantify sales, although on the average error does not appear large as the data indicates -- about 25 percent of the calves were kept for replacements.[57]

Table 6. Percent of calves produced each year that are sold at weaning time, as yearlings and as two-year-olds[a]

Strata (AUs)[b]	1	2	3	4	Pooled
Weaning					
Mean	18.5	15.4	38.9	24.7	24.4
Std. error	7.7	8.6	12.5	10.5	5.0
Yearlings					
Mean	55.7	62.8[c]	27.9	32.2	44.7[d]
Std. error	10.2	7.9	9.8	9.9	5.1
Two-year-olds					
Mean	1.5	4.5	5.8	17.4	7.3
Std. error	1.2	2.9	5.2	10.1	3.0
Total sold	75.7	82.7	72.6	74.3	76.4

[a]In all strata N = 11.

[b]The number of animal units in each stratum is given in Table 2, page 46.

[c]Mean value is significantly different than the corresponding means in strata three and four (5% level).

[d]Highly significantly different from other two pooled means (1% level).

Only in the case of the proportion of yearlings sold does there appear to be any significant difference between different sized operations.

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57 If replacements each year comprise about 17% of breeding females (to be seen subsequently) and calf crop is 86% and cull rate is perhaps 8 or 9% at present rate of buildup, then 86/100 x 92 = 77 calves, 17 of which or 22%, go for replacements suggesting a slight downward bias in the figures of Table 9.

The smaller operators sold more of their young beef product as yearlings. The larger operators sold proportionately more of their product as calves or two-year-olds.

The means of the pooled strata were tested for differences. The sample indicated with a high degree of significance that Peace River operators prefer to sell yearlings.

Selling procedure was examined with operations stratified according to the variable "percent feeder animal units/total animal units" x 100 gave the results of Table 7.[58] The figures indicated that as the percentage of feeders in the operation becomes larger, the calves produced were sold at an older age. Within stratum one, the stratum in which least emphasis was placed on the feeder operation, operators still reported selling 30.3 percent of their young stock as yearlings. This result can be accounted for by the method of computing average animal units.[59] Pooled data is identical to that of Table 6.

Characteristics of the strata

Table 8 gives the means and ranges within strata of the variable, animal units and its two components breeding animal units and feeder animal units. The mean percentage that feeder animal units were of total animal units within each stratum is given in the second to last row of figures. Note that the percentage of feeders was distributed almost uniformly among four strata when the basis for stratification was the number of animal units.

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[58] See page 28, "restratification."

[59] See page 30. Time and size was considered. By the method one calf would have to be kept for 20 months from November first to equal one feeder AU. Even at relatively low percentages of feeder AUs, fairly large numbers of feeders may be retained for some months.

Table 7. Percent of calves <u>produced</u> each year that are sold, at weaning time, as yearlings, and as two-year-olds based on feeder strata

Strata (percent of feeders) $\left(\frac{\text{Feeder AUs} \times 100}{\text{Total AUs}}\right)$	1 0-9.9	2 10-19.9	3 20-55.3
Weaning			
Mean	43.7	11.1	13.0
Std. error	8.5	7.4	7.0
N	17	12	15
Yearlings			
Mean	30.3	57.5	50.6
Std. error	8.2	6.8	9.5
N	17	12	15
Two-year-olds			
Mean	0.6	3.2	13.3
Std. error	0.4	2.3	8.0
N	17	12	15

Table 8. Distribution of animal units and number of breeding females at time of interview among over-all size strata used for analysis

Strata (AUs) Animal units	1 0-33.5	2 33.6-59.5	3 59.6-89.5	4 89.6+	Pooled
Total AUs					
Mean	26.6	49.6	73.4	156.4	76.5
Range	12-33	36-59	61-89	101-273	12-273
Breeding-interview time					
Mean	21	41	66	136	66
Range	10-32	26-57	42-90	83-225	10-225
Breeding AUs[a]					
Mean	21.9	40.2	62.2	124.6	62.2
Range	11-29	28-51	39-84	87-230	11-230
Feeder AUs[a]					
Mean	4.7	9.4	11.2	31.9	14.3
Range	0-15	0-17	0-18	14-86	0-86
$\left(\frac{\text{Feeder AUs} \times 100}{\text{Total AUs}}\right)$[b]					
Mean	15.7	18.7	14.2	19.6	17.0
Range	0-44	0-30	1-55	1-44	0-55

[a]Means do not total due to rounding.

[b]Divisions for this variable were made on each observation hence its mean cannot be calculated from the means of its components.

Some Important Measures of Performance

Calf crop

The calf crop for 1963 was based on the number of calves at interview time. Mortality from July 31 to November first was low, and an excellent estimate was obtained for this one year. Though an excellent estimate was available for number of calves at November first of 1962, the estimate of number of cows being kept from which calves were expected, those available in December of 1961, was subject to memory bias. Emphasis was not placed on the calf crop figures for 1962 (Table 9.).

When stratification in Table 9 is based upon percent of feeders in the herd, the mean of 90.1 percent calf crop in stratum three differs significantly from the means of strata one and two. However, if a confidence interval of plus or minus two and a half times the standard error is taken as the 95 percent level for the 90.1 mean and plus or minus two times the standard error as the confidence interval of the pooled mean of 85.2, the confidence intervals of the two means overlap. Hence herds containing 20-55 percent feeder cattle did not obtain a calf crop percentage significantly different from the average of all those sampled. The hypothesis that larger operators obtain smaller (or larger) calf crops on a percentage basis is not supported within the size range of operations studied.

Operators supervised calving closely as cows were, as a rule, still confined for winter feeding when the majority of calves arrive.

Death loss

Table 10 reports death loss with causes unspecified. The occasional missing animal has been included in losses. No significant differences were found between means.

Table 9. Calf crop percentages by over-all size strata, and by percent feeder strata, 1962 and 1963

	Calf crop 1963			Calf crop 1962		
	Mean	Std. error	N	Mean	Std. error	N
Strata (AUs)[a]						
1	85.0	3.8	11	88.6	1.7	11
2	88.7	2.3	11	89.6	3.6	8
3	81.4	4.9	11	90.1	2.8	6
4	85.9	2.8	11	85.8	3.9	6
Pooled	85.2	1.8	44	88.6	1.4	31
Strata (% feeders)[b]						
1	83.3	2.7	17	87.8	2.2	14
2	81.0	4.2	12	93.3	1.6	8
3	90.1*	2.1	15	86.0	2.9	9

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]The percentage range of feeders in each stratum is given in Table 7, page 51.

*Significantly different from means of stratum one and two at the 5% level.

Table 10. Percent losses, all classes beyond age of six months

Strata (AUs)[a]	1	2	3	4	Pooled
Mean	2.4	1.6	2.0	1.0	1.7
Std. error	0.8	0.6	0.5	0.2	0.3
N	11	11	11	11	44

[a]The number of animal units in each stratum is given in Table 2, page 46.

Gain or loss of weight on pasture

Each operator was asked to estimate how much his mature cows gained on pasture from their spring turn-out weight to the time winter feeding began. The results are tabulated in Table 11. No significant differences were found between means.

Table 11. Number of operators reporting weight loss or gain on mature cows over the pasture period (operators' estimates)

Strata (AUs)[a]	1	2	3	4	Pooled
Gain	5	8	4	8	25
Loss	1	0	2	0	3
No change	3	1	2	2	8
No info.	3	2	3	1	8
Mean gain (lbs.)[b]	50	145	56	105	90
Std. error	24	29	52	26	17

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Only on those providing information.

<u>Weight of cull cows and bulls</u>

The weights of cows sold on any one farm were averaged. This average was weighted by the number of cows sold on each farm to compute the average within strata. Although the mean of stratum one tested significantly larger than the other means, the result was likely spurious as this mean was increased by the actions of one operator with heavy cows who reduced his herd drastically. As point of interest included in Table 12 is the operators' estimates of the usual sale weights of their cull cows and their estimate of the percentage that are sold because they are disabled.

For budget purposes an estimate of the sale weight of cull bulls was obtained since sufficient numbers of this class were not sold to generate a reliable mean. The upward bias of operator estimates revealed for cull cow weights, at least on the basis of one years sales, can be assumed to apply to bulls. If, as indicated, smaller operators did sell a much higher percentage of their cull cows when broken down and disabled, a real difference in culling practices was indicated.

Table 12. Means of weights in pounds of cull cows sold July 1962-July 1963, operators' estimates of sale weights of cull cows and bulls, and operators' estimates of percentage of disabled cull cows

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (cows actual)	1180[b]	1110	1110	1140	1140
Std. error	22	15	12	9	7
N[c]	39	45	53	125	262
Mean (cows estimate)	1220	1210	1230	1130	1200
Mean (bulls estimate)	1790	1780	1680	1710	1730
Cull cows disabled (%)	66[d]	27	24	15	31
Std. error	10.7	8.3	5.6	4.6	4.7
N	8	10	9	10	37

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Highly significant difference between means of strata two and three and significantly different from mean of stratum four.

[c]N does not represent all cows sold within strata as purchased feeder cows are excluded.

[d]Highly significant difference between means of strata three and four and significantly different from mean of stratum two.

Weights of young stock sold

In Table 13 the mean sale weight of an operator's animals was weighted by one to compute the over-all mean. The means were calculated only on the animals produced on the farm; purchased feeders were excluded. No record was obtained of the different feeding practices used to attain these weights.

Beef output and TDN requirements

No significant differences were found in the mean output of beef per animal unit stratified by over-all size. However, stratification by animal units revealed a statistically significant upward trend in dollars

of beef produced per animal unit as the percentage of feeders in the herd increased. Though significance at the five percent level was not achieved, an upward trend seemed to exist in pounds of beef produced per animal unit as the percent of feeders increased. Such results for the feeder stratification were expected.

Table 13. Selling weights for age of beef calves and yearlings, Peace River area 1962-63 - produced on the farms

Age (Months)	Mean	Std. error	Range	N[a]
	pounds	pounds	pounds	
6	410	25	330-440	5
7	410	20	350-480	7
8	465	34	330-550	6
10	720	88	610-890	3
11	627	47	400-780	7
12	730	41	600-840	5
13	730	67	430-920	6
14	810	22	660-870	9
16	760	24	700-820	6
23	920	37	850-960	3

[a]N is the number of operators selling animals produced by them at the given age.

In Table 14 the range of performance as measured by output per animal unit was large. The wide range of selling weights observed was attributable to differences in feeding and management practices and to variation among individual beef animals with respect to rate of daily gain.

A similar variation existed for feed required for beef production. Again significant differences were found in the percent feeder stratification, suggesting that less feed (TDN) was required to produce beef as the proportion of feeders increased (Table 15).

Table 14. Pounds and value of beef produced per animal unit stratified by animal units and percent feeder animal units

Pounds of beef produced per animal unit

Strata (AUs)		Mean	Std. error	Range	C/V	N
0-33.5	(1)	544	47	222-728	28	11
33.6-59.5	(2)	520	35	323-655	20	9
59.6-89.5	(3)	454	24	371-576	15	8
89.6 and over	(4)	457	47	120-602	32	10
Pooled		497	21	120-728	26	38
Strata (% feeders)						
0-9.9	1	453	24	222-599	21	16
10-19.9	2	515	38	323-675	22	9
20-55.	3	538	45	120-728	30	13

Value of beef produced per animal unit

Strata (AUs)	Mean	Std. error	Range	C/V	N
	dollars	dollars	dollars	percent	
(1)	124	15.40	42-222	41	11
(2)	120	7.80	84-144	20	9
(3)	94	4.90	77-120	15	8
(4)	100	5.30	75-121	17	10
Pooled	110	5.40	42-222	30	38
Strata (% feeders)					
1	95*	5.70	42-144	24	16
2	112	8.40	84-167	23	9
3	129	11.00	75-222	31	13

*The difference between this mean and that of stratum three is highly significant.

Table 15. Pounds of TDN from all sources for each 100 pounds of beef produced - derived from operator's reports of feed used.

Strata (AUs)[a]	Mean	Std. error	Range	C/V	N
(1)	1480	151	890-1760	34	11
(2)	1280	89	1010-1730	20	8
(3)	1335	49	1180-1570	10	8
(4)	1286	101	870-1860	25	10
Pooled	1350	57	870-1860	26	37
Strata (% feeders)[b]					
1	1550*	94	1180-1860	16	24
2	1140	64	870-1410	8	16
3	1180	69	890-1730	13	20

[a]The number of animal units per stratum is given in Table 2, page 46.

[b]The percentage range of feeders for each stratum is given in Table 7, page 51.

*Highly significant difference between the mean of stratum two and significantly different from the mean of stratum three.

Practices and Operating Procedure

Replacement rates[60]

The figures for final replacement rate were of greatest interest for budget purposes, for they attempt to define replacement rate under stable herd size, and after first year breeding heifers have been culled.

The actual replacement rate was of interest since it represented historical replacements over the past two years (1962 and 1963). This rate did not appear to be wholly consistent with data of Table 4 concerning herd size increases. However, no significant differences were found between means.

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60 See page 30 for definitions and discussion.

Culling rate

Only one such rate was computed which corresponds to the final replacement rate in Table 16. Each enterprise was examined for the month in which the largest sale of cull cows occurred. Major sales on particular enterprises ranged from September to July inclusive; the average month of sale was January. The modal month of sale was November.

Table 16. Replacement rates in percent - Peace River area - 1962-63

Strata (AUs)[a]	1	2	3	4	Pooled
Initial rep. rate					
Mean*	18.9	16.0	14.9	15.1	16.5
Final rep. rate					
Mean	17.3	13.2	14.3	13.3	14.7
Mode	13.9	9.7	10.9	10.6	10.6
Std. error	1.4	1.7	1.3	1.5	0.8
N	11	11	7	7	36
Actual rep. rate					
Mean	13.8	17.2	18.3	17.5	16.6
Mode	15.3	20.7	25.8	14.4	22.5
Std. error	1.8	2.6	2.4	1.9	1.1
N	11	10	9	11	41

[a]The number of animal units per stratum is given in Table 2, page 46.
*Difference between means not tested.

Management of bulls

Cow/bull ratio In Table 17 note that the larger operators have about 37 females to a bull. If bull inputs were continuously variable, the smaller operators would likely use about the same ratio so little significance can be attached to these means. Table 8 gives the number of breeding females within strata on which these means are based.

Table 17. Cow-bull ratio, breeding season of 1963

Strata (AUs)[a]	1	2	3	4	Pooled
Mean*	20.7	30.7	37.0	36.8	31.3
Range	10-32	20-40	22-60	21-55	10-60

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Difference between means not tested.

<u>Dates bulls are with cows</u> Although significant differences between means were not found, the data of Table 18 indicated that smaller operators turned bulls in earlier and took them away from the cows later than did larger operators. A calculation based on an average of the difference between turn-in and turn-out dates may have registered significance.

The data on turn-out dates would be more meaningful if means were calculated with the thirteen observations removed in which bulls were with cows for all but the calving period.

Table 18. Normal turn-in and turn-out dates for bulls

Strata (AUs)[a]	1	2	3	4	Pooled
Turn-in					
Mean	May 26	June 6	June 15	June 15	June 6
Range	Mar. 19-June 25	May 31-June 20	Apr. 30-June 20	May 16-July 16	May 16-July 16
Turn-out					
Mean	Jan. 10	Dec. 4	Nov. 21	Oct. 3	Nov. 21
Range	Sept. 15-Mar. 28	Aug. 31-Mar. 28	Aug. 31-Mar. 28	Aug. 15-Apr. 26	Aug. 15-Apr. 26
Difference between mean dates (days)	230	181	165	114	170

[a]The number of animal units in each stratum is given in Table 2, page 46.

<u>Other aspects of bull management</u> The operators in the sample generally used bulls which cost about 500 dollars. These bulls were retained for about three years with little variation occurring between strata. Bulls sold for slaughter were marketed in late winter or early spring. March was the average month of sale for all operators. About one half of the operators who provided usable information reported that their cull bulls were still in useful breeding condition and were frequently sold for breeding purposes. A summary of operator replies concerning the sale of cull bulls is given in Table 19.

Table 19. Number of operators reporting and destination of cull bulls according to operator estimate

Strata (AUs)[a]	1	2	3	4	Pooled
Sell for slaughter	4	3	2	3	12
Sell for breeding	4	1	5	3	13
Either breeding or slaughter	1	3	1	1	6
No information	2	4	3	4	13

[a]The number of animal units per stratum is given in Table 2, page 46.

While cows were fed roughage for 184 days on the average, the corresponding figure for bulls was 222. Bulls were generally kept in and fed dry feed up until the time they were placed with the cows. Since larger operators tended to turn in bulls later, they must feed them longer in the spring. The mean feeding period for bulls was 207 and 236 days, respectively, for strata one and four.

<u>Date of weaning</u>

In most cases calves were weaned in the first week of November, although a few operators would wean as early as mid October and as late as December. The standard error was 5.1 days over 40 observations.

<u>Days on stubble</u>

When grain fields became available after harvest, most operators gave their cattle access to them prior to the start of winter feeding. The mean number of days on stubble was 29. There were seven operators who did not and in some cases would not give cows access to cultivated fields. When these observations were removed the mean time on stubble was 35 days with maximum and minimum observations of 10 and 70 days, respectively. The two operators who left cows in the fields for extended periods had straw stacks available.

<u>Other management practices</u>

The more interesting results of questions concerning various practices were tabulated in the following tables. Because the characteristics being dealt with did not allow for accurate measurement, only the number of operators engaged in certain practices was reported. This procedure did lend itself, however, to testing for differences between proportions.

<u>Heifer management</u> Data in Table 20 indicates that about half the operators in all strata separated cows and yearling heifers on pasture, although most used the same bull. About one half of the operators did not have better quality pasture available for heifers. The use of different bulls in nearly all cases refers to younger bulls rather than bulls of a different breed.

Table 20. Number of operators engaged in selected pasturing and breeding practices with yearling heifers

Strata (AUs)[a]	1	2	3	4	Total
In different pasture than cows	5	6	6	4	21
In same pasture as cows	6	5	4	7	22
No information	0	0	1	0	1

Distribution of operators using different pasture

Strata (AUs)[a]	1	2	3	4	Total
Using better pasture	1	2	2	2	7
Using same quality	3	3	3	2	11
No information	1	1	1	0	3

Breeding practices for yearling heifers, all operators

Strata (AUs)[a]	1	2	3	4	Total
Use different bulls than for cows	2	2	5	3	12
Use same bulls as for cows	6	5	4	8	23
Do not breed yearlings	3	4*	1	0	8
No information	0	0	1	0	1

[a]The number of animal units in each stratum is given in Table 2, page 46.

*The proportion of 4 out of 11 who did not breed yearlings in stratum two is significantly different from the proportion of 0 out of 11 who did not breed yearlings in stratum four (5% level).

Small operators were more adverse to the breeding of yearling heifers than large operators. Small operators did, not, however have the same opportunity for flexibility regarding the handling of yearling heifers.

When similar questions were asked concerning the management of two-year-old heifers nursing their first calf, eleven operators said they separated them from the cows but only for calving. Twelve operators did

give pregnant yearling heifers special feeding during the winter (Table 21).

Table 21. Number of operators giving special winter care to pregnant yearling heifers

Strata (AUs)[a]	1	2	3	4	Total
Separate from cows	2	3	1	3	9
No special care	9	5	8	8	30
Separate periodically	0	1	2	0	3
No information	0	2	0	0	2

[a]The number of animal units in each stratum is given in Table 2, page 46.

Culling Responses to questions such as those for which enumeration was made in Table 22 may be biased as a result of question phrasing and the respondent's replying with what he thinks he should be doing. Nevertheless, from Table 22 and data unreported here it seemed that about one fourth of the operators cull all females that do not produce a calf. Reasons for culling cows are ranked in their order of importance: (1) failure to produce a calf; (2) the cow produced a poor calf; (3) the cow was old and breaking down, and (4) the cow had poor conformation. Certainly Table 22 indicates, that operators will keep a cow as long as she appears capable of producing another calf.

Thirteen operators would sell their cull cows off-grass in the fall. Twelve preferred to feed them and sell in midwinter. Eight sold in the spring, and three said they sold off cull cows in mid summer.

Changing practices In the past three years fifteen operators had made various changes in their breeding practices. Four were using better bulls. Seven had started using younger bulls for breeding heifers. Three were keeping heifers separate from the cows, and one was starting to use

polled bulls.

Table 22. Enumeration of responses to questions on culling practices, questions abbreviated

Do you cull all dry cows?

Strata (AUs)[a]	1	2	3	4	Total
Yes	5	3	3	7	18
No	5	5	5	2	17
Depends	1	0	2	2	5
No information	0	3	1	0	4

Will you give young cows another chance?

Strata (AUs)[a]	1	2	3	4	Total
Yes	7	9	5	5	26
No	4	0	3	3	10
Sometimes	0	1	3	1	5
No information	0	1	0	2	3

Do you cull all cows over a certain age?

Strata (AUs)[a]	1	2	3	4	Total
Yes	2	0	1	1	4
No	9	10	8	5	32
No information	0	1	2	5	8

[a]The number of animal units in each stratum is given in Table 2, page 46.

Eight had made feeding changes which included methods of roughage preparation (silage), changing proportions of legume hay and straw fed (more straw), and the introduction of protein supplement and vitamin A into the ration.

Eight had also made changes in marketing. Five of the eight were marketing younger animals; three were selling either to a different market

or making some minor change such as trucking their own stock.

Concerning planned changes in the next three years, nine planned breeding changes including the use of better bulls, breeding heifers at a younger age, confining bulls after the breeding season, and the use of crossbreeding techniques. Four indicated they expected to make needed improvements in watering facilities, corrals, or other livestock equipment.

Seventeen operators planned to make feeding changes. Five were going to start putting up silage, another five expected to develop more feed resources (more tame pasture, drainage, etc.) The remaining seven planned to start crop feeding or other feed supplementation practices.

The eight respondents who planned marketing changes were divided equally in their intentions to sell younger animals and to sell older animals. Five operators planned to expand their feeder operation by buying calves or yearlings.

Feed Inputs

Feed quantities reported are those actually used as far as could be ascertained. Operators were asked if the past winter (1962-63) was a normal winter, and if not, what quantities of roughage would have been fed. The results tabulated in Table 23 suggest that in the opinion of cattlemen in the area roughage quantities used in the winter of 1962-63 were near normal. Only three of the largest operators thought the winter was considerably harder than usual as evidenced by their estimate of 26 percent less roughage being required in a normal winter. Examination of weather data for the winter in question would be desirable.

Most operators used up the major part of their supply of roughage, for planning for a large carryover was not a practice in the area. If a surplus of hay or straw became apparent during the latter part of winter,

Table 23. Operator estimates of roughage quantities required in a normal winter compared to roughage quantities used in winter of 1962-63

Strata (AUs)[a]	1	2	3	4	Pooled
Same (operators)	5	8	4	6	23
More (operators)	2(6%)[b]	0	1(10%)	1(15%)	4
Less (operators)	2(4%)	0	3(15%)	3(26%)	8
No information	2	3	3	1	9

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Figure in brackets indicates the mean percentage by which the number of operators in that stratum thought quantities used in 1962-63 would have to be changed for a normal winter.

a number of operators suggested they were more wasteful in its usage because they thought that it would not keep in a satisfactory condition for use next year. If roughage was in limited supply, operators were willing to supplement the ration with concentrates.

Few operators were approaching their roughage preservation problems by building hay shelters, using plastic sheeting, or by making silage (Table 24).

Table 24. Number of operators putting up silage now and planning to put up silage in the next three years, and number using hay shelter

Strata (AUs)[a]	1	2	3	4
Make silage	1	1	3	1
Planning silage	1	1	2	1
Use hay shelter	4	2	3	0
Hay sheltered (mean percentage)*	29	46	57	-

[a]The number of animal units in each stratum is given in Table 2, page 46.

*Mean of the percent of hay sheltered of those sheltering hay.

Of those operators who provided information on roughage carryover, no significant differences were found between strata for the mean percentage carryover for the year under observation (Table 25). Notably over half of those who provided information on carryover did not have any roughage reserves by spring.

Table 25. Number of operators with and without roughage carryover and percent roughage carryover of those who had a carryover compared to roughage used, winter 1962-63

Strata (AUs)[a]	1	2	3	4	Pooled
Had carryover	3	3	6	6	18
No carryover	7	4	4	5	20
No information	1	4	1	0	6
Percent carryover (mean)	13.4	10.9	26.8	15.6	18.2
Std. error	1.7	1.7	9.9	9.7	4.6

[a]The number of animal units in each stratum is given in Table 2, page 46.

Roughage and bedding use

Since every operator did not provide sufficient information to make division of feed among all livestock classes possible, the figures in Table 26 were calculated on the number of animals in the over-all breeding herd. Each cow, heifer, bull, and replacement calf was weighted as one. Feed had to be divided between the breeding herd and the feeders for this calculation. Five operators who turned their cows and heifers on straw or chaff piles were separated because their quantities of roughage fed, aside from straw piles, differed greatly from the amounts fed by those who did not use straw piles.

When animal units were used as the basis of comparison for roughage and bedding use, no differences were found between means. Roughage fed

per animal unit was 2.7 tons while the estimate of bedding use was 0.6 tons. These estimates were larger than those given in Table 26 because conversion to animal units decreased divisor size.

Table 26. Roughage fed and bedding straw used for each animal in the breeding herd

Roughage fed by operators not using straw piles

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	2.2	2.3	2.3	2.3	2.3
Range (tons)	1.7-3.5	1.2-3.6	1.8-2.8	1.3-3.7	1.2-3.7
N (operators)	9	7	7	10	33

Roughage fed by operators using straw piles

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	-	-	1.2	-	1.2
N (operators)	1	1	3	0	5

Bedding straw used by operators not using straw piles

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	0.6	0.5	0.3	0.3	0.4
Range (tons)	0-2.3	0-0.9	0-0.7	0-1.4	0-2.3
N (operators)	9	7	4	10	30

[a]The number of animal units in each stratum is given in Table 2, page 46.

Roughage proportions Roughage fed was divided into four categories: (1) that containing some proportion of legume; (2) grass hay (brome, fescue); (3) cereal hay (greenfeed); and (4) straw (including forage seed crop straw). Table 27 indicates how operators on the average apportioned the different classes of roughage to their stock.

Table 27. Mean proportions in percent of roughage classes fed the various beef classes

Roughage Class	Legume Mix	Grass	Greenfeed	Straw
Cows and heifers	43	15	17	25
Herd bulls	57	18	16	9
Replacement calves	64	8	19	9
Feeder calves	55	9	26	10
Feeder yearlings	67	11	8	14

Cows and heifers The data of Table 27 represents the pooled data of all strata. It was expected that larger operators would use a greater proportion of straw than the smaller operators. No significant differences were found between strata.

No significant differences between strata were found for the total quantity of roughage fed to each cow and heifer wintered. Again the original hypothesis was not supported (Table 28).

The quantities reported appear to be more than adequate, but the operators complained of poor quality feed. Morrison's standards, which allow for a margin of safety, suggested sixteen to 25 pounds of roughage daily for this class of stock.[61] Depending upon hay quality, as much as one pound of protein supplement may be added. Operators in the Peace River Area also fed an average of 1.9 pounds of concentrate daily during the winter feeding period. National Research Council, which bases its recommendations on requirements rather than allowances, suggested eighteen pounds of good quality feed daily.[62]

61 Morrison, 22nd ed., p. 1120.

62 Nutrient Requirements of Beef Cattle, p. 2

Table 28. Total roughage fed to each cow and heifer over winter and amount fed daily (roughage fed by operators not using straw piles)

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	2.4	2.4	2.5	2.4	2.4
Range	1.8-3.7	1.2-3.7	2.0-2.9	1.4-4.0	1.2-4.0
N	9	7	8	9	33
Lbs. daily (mean)*	25	25	26	26	26

Roughage fed by operators using straw piles

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	-	-	-	-	1.2

[a]The number of animal units in each stratum is given in Table 2, page 46.

*Based on number of days actually fed, winter 1962-63.

Herd bulls Few conclusions were obtained from the data of Table 29 concerning differences between strata in the feeding of bulls. Herd bulls were fed in excess of NRC daily standards of 25 pounds of feed, which would include some concentrate to bring the ration up to the 58 percent TDN figure.[63] Herd bulls in the Peace River area received an average of 5.4 pounds of concentrate daily over the time they were fed roughage.

Replacement calves The roughage fed to calves as given in Table 30 agreed closely with Morrison's recommendations.[64] Since the best hay was usually given to calves, perhaps normal amounts were sufficient. Replacement heifer calves were fed concentrates at the rate of about 5.0 pounds daily -- considerably above Morrison's recommendations of

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63 Ibid, p. 5.

64 Morrison, op. cit., p. 1120.

Table 29. Total roughage fed, days fed and amount fed daily to each herd bull

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	3.1	3.3	3.1	4.4	3.6
Std. error	0.23	0.62	0.32	0.77	0.34
N	4	6	5	9	24
Days fed (mean)[b]	207[c]	228	215	236	222
Lbs. daily (mean)[d]	30	30	28	36	32

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Days actually fed during the winter 1962-63.

[c]Significantly different from the mean of stratum four.

[d]Mean calculated from individual data, not by division of means here.

Table 30. Total roughage fed and daily amount fed to each replacement heifer calf

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	1.0	1.6	1.2	1.2	1.2
Std. error	0.10	0.30	0.12	0.11	0.08
N	7	6	9	9	31
Lbs. daily (mean)[b]	10.5[c]	16.8	12.5	12.6	12.9

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Based on number of days actually fed, winter 1962-63.

[c]Significantly different from the mean of stratum two.

up to two pounds. Few operators separated replacement calves from those being prepared for market hence replacements often received a too liberal grain allowance. Winter gains of replacement heifers were likely equal to or greater than those given by NRC -- 1.5 pounds daily.

Feeder calves A comparison of roughage consumption data for feeder calves in Tables 30 and 31 indicates somewhat less fed to feeders than to replacements. This difference was more than compensated for by an average of 5.7 pounds concentrate fed daily to feeder calves over the period indicated.

Table 31. Total roughage fed, days fed and amount fed daily to each feeder calf

Strata (AUs)[a]	1	2	3	4	Pooled
Mean (tons)	0.96	1.2	1.1	1.1	1.1
Std. error	0.21	0.22	0.17	0.25	0.11
N	8	6	6	8	28
Days fed (mean)[b]	194	180	217	201	198
Lbs. daily (mean)[c]	10	14	10	10	11

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Days actually fed in survey year.

[c]Calculated from individual data.

Feeder yearlings Suitable data was limited for this class hence only pooled averages were given in Table 32. The mean of fourteen pounds of hay fed daily was combined with a mean quantity of 8.9 pounds of concentrate daily. Because a large proportion was oats, this ration must be considered more for growing than for fattening.

Table 32. Total roughage fed, days fed and amount fed daily to each feeder yearling

	Total roughage (tons)	Days fed	Lbs. fed daily
Mean	1.0	141	14
Std. error	0.22	13.5	2.1
N	13	13	13

Concentrates

Table 33 gives the proportions of the three main grains used in feeding the different livestock classes.

Table 33. Mean proportions in percent of wheat, oats and barley fed the various beef classes

Grain	Wheat	Oats	Barley
Cows and heifers	1	74	25
Herd bulls	2	64	34
Replacement calves	2	61	37
Feeder calves	2	52	46
Feeder yearlings	2	25	73

Table 34 presents only pooled data on mean days actually fed and the mean daily concentrate ration for the various classes. Significant differences were found only between strata means for cows and heifers. The smaller operators tended to feed each cow or heifer more concentrate daily and also to feed for a greater number of days.

Table 34. Weight of concentrate fed daily and number of days concentrate was fed to each animal in the various beef classes

	Mean	Std. error	N[a]
Cows and heifers			
Weight (lbs.)	2.9	0.37	42
Days fed	88	11.0	42
Bulls			
Weight (lbs.)	8.3	0.73	38
Days fed	149	12.3	39
Replacement calves			
Weight (lbs.)	4.8	0.57	34
Days fed	175	9.7	35
Feeder calves			
Weight (lbs.)	5.7	0.67	28
Days fed	189	12.5	28
Feeder yearlings			
Weight (lbs.)	11.6	1.7	13
Days fed	108	15.0	13

[a]N equals the number of beef producers providing data.

For the TDN measures reported in Table 35, the grain proportions fed on each farm were weighted by their respective TDN factors and by the number of days each class was fed.

For every beef class with the exception of bulls and yearling feeders (no data being available on the latter class) the operators in strata one fed the greatest quantity of concentrate per animal. Significant differences between strata were found only in the case of cows and heifers. The gradation in means was reasonable and supported an original hypothesis that smaller operators tend to feed larger quantities of concentrate to cows. On the other hand, the treatment given herd bulls was at variance with that for cows and heifers.

Table 35. Total pounds of concentrate in TDN fed each animal in the various beef classes over their respective feeding periods

Strata (AUs)[a]	1	2	3	4	Pooled
Cows and heifers					
Mean	458[b]	254	129	129	245
Std. error	70.0	59.0	52.7	63.1	36.7
N	11	10	10	11	42
Bulls					
Mean	607[c]	917	748	1204	875
Std. error	148	227	145	225	98
N	9	9	10	10	38
Replacement calves					
Mean	1086	526	672	543	702
Std. error	314	85	188	128	102
N	8	6	9	11	34
Feeder calves[d]					
Mean	1096	674	921	779	878
Std. error	329	212	251	267	136
N	8	6	6	8	28
Feeder yearlings[d]					
Mean	-	-	-	-	1095
Std. error	-	-	-	-	154
N	1	3	4	5	13

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Highly significantly different from the means of strata three and four and significantly different from the mean of stratum two.

[c]Significantly different from the mean of stratum four.

[d]The relevant feeding period for concentrates would usually begin in the fall and in some cases might extend well into August of the next year.

<u>Protein, mineral, and vitamin supplements</u>

No significant differences were found between strata in their use of supplements with one exception given in Table 36. All data was reported on the basis of pounds used per animal unit in a one year period.

On the average operators used 23 pounds of salt per year, a figure which is reasonable--Morrison suggested that 20 to 30 pounds might be the relevant range.[65] When the data was stratified by feeder animal units, no change was found.[66]

Resource imbalance existed in the case of protein supplement. Only ten operators fed protein supplement; these zero inputs are included for calculating the means of Table 36. The mean use of protein supplement by these ten was 25 pounds per animal unit. Their usage ranged from 0.4 to 66 pounds per AU. When operators were examined individually concerning protein supplement contribution, it was estimated that the marginal rate of substitution of protein supplement for grain ranged from 2.7 to 5.3.[67] With oats, barley, and protein supplement prices of 1.7, 1.5, and 6.0 cents per pound, respectively, for the area, the price ratio, depending upon the proportions of oats and barley (Table 33), is between 3.5 and 4.0. Although precise recommendations cannot be made, these estimates suggest that those feeding young stock could reduce production costs by substituting protein supplement for grain to drive the substitution

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65 Morrison, <u>op</u>. <u>cit</u>., p. 699.

66 Stratum one was that which represents those operators with the lowest proportion of feeder AUs.

67 For procedure see Heady and Dillon (5), p. 463-465.

ratio down to the price ratios indicated. Only two operators were estimated to have driven the substitution ratio below the price ratio; the price was driven down only on one class of stock, for other classes on the same farm may receive little or no protein supplement.

The mean of 6.8 pounds of calcium and phosphorus supplements fed each animal unit over the year would suggest that supplementation here was satisfactory. Studies reported by Morrison suggested fifteen to seventeen grams of phosphorus per day as being satisfactory on range.[68] The quantity of phosphorus given in supplements would supply this rate for nearly 300 days, assuming no wastage and ignoring the phosphorus contribution of grains. On the average a sufficient quantity of calcium was supplied.

Operators on the average were apparently well advised regarding the use of vitamin A, although fifteen did not use any. The mean of 0.43 pounds per animal unit would supply each animal unit with 20,000 I.U. per day for just over three months.

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[68] Morrison, op. cit., p. 702.

Table 36. Pounds of supplement used per animal unit in the survey year

Strata (AUs)[a]	1	2	3	4	Pooled
Salt					
Mean	28[b]	26	21	17	23
Std. error	5.7	4.0	3.0	2.1	2.1
N	11	9	9	11	40
Protein[c]					
Mean	8.0	4.9	9.4	10.0	6.1
Std. error	3.5	4.6	0.9	6.8	2.3
N	11	9	10	11	41
Ca-P[d]					
Mean	8.3	6.0	2.5	9.8	6.8
Std. error	3.1	1.8	8.0	4.0	1.4
N	11	10	10	11	42
Vitamin A[e]					
Mean	0.67	0.50	0.21	0.38	0.43
Std. error	0.17	0.14	0.12	0.11	0.071
N	10	9	10	11	40

Strata (Feeder Aus)[f]	1	2	3
Salt			
Mean	22	24	23
Std. error	2.0	3.8	4.6
N	16	9	15
Protein			
Mean	1.7	4.3	13
Std. error	0.78	2.9	6.0
N	17	10	14
Ca-P			
Mean	4.8	4.0	11
Std. error	1.3	1.3	3.5
N	17	10	15
Vitamin A			
Mean	0.42	0.29	0.54
Std. error	0.12	0.12	0.12
N	16	10	14

Table 36. Continued

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Significantly different from the mean of stratum four.

[c]TDN 75% and digestible protein 37%

[d]Averages mostly composed of bonemeal, small amounts of ground limestone and dicalcium phosphate, mineral content perhaps 32% Ca and 15% P.

[e]Containing 10,000 I.U. vitamin A per gram.

[f]The percentage range of feeders in each stratum is given in Table 7, page 51.

Land Inputs

The cultivated acreages in use for beef production given in Table 37 were as reported by the operators. The categories as reported were substitutes for each other since, for example, hayland aftermath may be used for grazing. Also grazing on residue from forage seed crops was used for beef production by widely varying amounts on individual farms. No correction could be devised. Moreover, acreages were biased upwards because no correction was made for milk cows or pleasure horses as was done for winter roughage quantities. Differences between means, some of which were highly significant, show that the smallest operators depended mostly upon their cultivated acreages. Land used for greenfeed production decreased uniformly as operation size increased, supporting a previous observation made in the feed section. Only four operators employed cover crop. Since stratification by proportion of feeder animal units revealed no significant differences, the data was not reported.

Table 37. Acres of cultivated land (all qualities) used per animal unit for the production of winter and summer forage[a]

Strata (AUs)[b]	1	2	3	4	Pooled
Tame hayland					
Mean	1.7	1.6	2.2[c]	1.3	1.7
Std. error	0.23	0.24	0.38	0.25	0.15
Tame pastureland					
Mean	1.9[d]	0.50	0.92	0.40	0.93
Std. error	0.27	0.17	0.37	0.20	0.16
Forage seed crops					
Mean	0.58	0.43	1.2	0.22	0.60
Std. error	0.33	0.27	0.99	0.14	0.26
Greenfeed					
Mean	0.71[e]	0.47	0.39	0.22	0.45
Std. error	0.19	0.16	0.19	0.11	0.083
Cover crop					
Mean	0.24	0.14	0.05	0	0.11
Range	0-1.4	0-1.4	0-0.5	-	0-1.4
Total					
Mean	5.1[f]	3.1	3.9	2.1	3.6
Std. error	0.51	0.50	0.49	0.34	0.28

[a]No corrections made for hay purchases.

[b]N in each case for the four strata respectively was 11, 10, 10, and 11.

[c]Significantly different from the mean of stratum four.

[d]Highly significantly different from the means of strata two and four and significantly different from the mean of stratum three.

[e]Significantly different from the mean of stratum four.

[f]Highly significantly different from the mean of stratum four and significantly different from the mean of stratum two.

Conclusions in the previous paragraph were supported by the data in Table 38 (note that the smallest operators as a group have the least amount of native or largely unimproved land available for pasture). Stratifying by proportion of feeder animal units did not reveal any significant differences.

Table 38. Acres of native and unimproved land (all qualities) used per animal unit and the mean of operators' estimates of the proportion of that land covered by bush

Strata (AUs)[a]	1	2	3	4	Pooled
N	11	10	10	11	42
Mean	6.4*	13	24	15	14
Std. error	1.6	2.2	6.0	2.7	1.9
Bush cover (percent)	76	50	55	67	60

[a]The number of animal units in each stratum is given in Table 2, page 46.

*Highly significantly different from the means of strata three and four and significantly different from the mean of stratum two.

Table 39 repeats some of the data of Table 37 but excludes two operators who purchased hay and includes the acreages of slough land harvested for hay by three operators.

Table 39. Acres per animal unit used for winter forage and bedding production

Strata (AUs)[a]	1	2	3	4	Pooled
Tame and wild hay					
Mean	1.7	1.6	2.0	2.0	1.8
Greenfeed					
Mean	0.71[b]	0.47	0.48	0.22	0.47
Straw[c]					
Mean	2.5[d]	1.3	1.4	1.9	1.8
Std. error	0.45	0.38	0.31	0.30	0.19
N	11	9	9	11	40

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Significantly different from the mean of stratum four.

[c]Acres estimated for all straw used whether for feed or bedding.

[d]Highly significantly different from the means of strata two and three.

Table 40 contains data on grazing rates for those operators whose pasture procedure could be followed. Perhaps the major conclusion to be drawn from the data was that cultivated pasture land was grazed three times as intensively as the native land. Price ratios differed greatly from the grazing ratios (See Appendix E).

After harvest on most farms the herd was allowed onto stubble fields for about a month. The mean number of acres of stubble provided per animal unit on the basis of 31 days was 8.3.

Table 40. Acres per grazing animal unit per 365 days for tame pasture and forage seed crops and for native pasture[a]

Strata (AUs)[b]	1	2	3	4	Pooled
Cultivated pasture					
Mean	7.4[c]	11	18	16	13
Std. error	1.0	4.0	6.7	2.0	2.0
N	5	3	4	4	16
Native pasture					
Mean	37	33	59	35	39
Std. error	3.9	3.9	23	2.7	4.6
N	4	10	4	4	22

[a]See footnote number 52 for definition of grazing animal units.

[b]The number of animal units in each stratum is given in Table 2, page 46.

[c]Highly significantly different from the mean of stratum four.

Labour Inputs

On the basis of operator estimates the smaller operators used more hours of labour than did the larger (Table 41). The differences exhibited were due to differences in technology, labour quality, and scale considerations. For example, it was noted that the smaller operators used more greenfeed hay, which was prepared with binders. This process took about four hours of labour per ton to prepare versus 1.6 to 3.5 hours per ton by the various combinations of baling methods depending upon length of haul and efficiency of the operators.[69] Labour

[69] Labour requirements are those given by Peace River area operators. See also Hughes, H.D., Heath, Maurice E. and Metcalfe, Darrel, S., eds. Forages. Ames, Iowa, Iowa State University Press. 1951. p. 553.

quality was not considered; a common supposition was that those on the smaller farms who also have the smaller herds accomplished less in a given time than those on the larger operations. Examples of economies of scale regarding labour usage are indicated in Table 41.

Table 41. Total hours of labour used per animal unit based on operator estimates

Strata (AUs)[a]	1	2	3	4	Pooled
Mean	56[b]	34[c]	25	22	35
Std. error	7.6	5.2	3.0	2.5	3.4
N	11	10	8	10	39

Strata (feeder AUs)[d]	1	2	3
Mean	45[e]	31	27
Std. error	6.9	4.0	3.5
N	16	9	14

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Highly significantly different from the means of strata three and four and significantly different from the mean of stratum two.

[c]Significantly different from the mean of stratum four.

[d]The percentage range of feeders in each stratum is given in Table 7, page 51.

[e]Significantly different from the mean of stratum three.

When stratified according to the proportion of feeder animal units, it was noteworthy that more labour was required per animal unit when the proportion of feeders was small.

Monthly distribution and job labour figures are presented in Appendix D.

Buildings and Livestock Equipment

Nearly all operators thought it essential to have some formally constructed shelter to protect very young calves during spring storms. Most thought it was advisable to have shelter available sufficient to protect most of the herd. The data in Table 42 indicate that on the average operators achieved the latter objective.

The decrease in barn space per animal unit as size of operation increased merely reflected that a barn was present on nearly every farm and that it was not constructed primarily for cattle shelter. On the other hand, shed space was increased as herd size increased.

No significant differences were found between strata with varying proportions of feeders, although shed space would appear to be increasing as the proportion of feeders increased.

Shed construction varied from those using poles supporting a straw roof to those of extremely heavy lumber construction using metal roofing.

The cash outlay, depreciation expense, and yearly cash repair expense for buildings and equipment are presented in Table 43. The smallest operators had invested significantly more in livestock equipment per animal unit than had those in the other strata. The result was partly a reflection of indivisibility of inputs. Watering facilities (dugouts), corral equipment, and various tools carried a large factor of indivisibility. Scale considerations applied also. For example, less fence per unit area was required to enclose a large field than a small one. As previously noted, the small operators provided much more shelter per animal unit than operators with large herds. Granting economies of scale for various factors, those in the first stratum still seemed to

Table 42. Square feet of barn space and shed space provided per animal unit

Strata (AUs)[a]	1	2	3	4	Pooled
Barn space					
Mean	34[b]	16[c]	10	6.0	17
Std. error	7.0	4.5	2.5	1.9	2.7
Shed space					
Mean	42	45	18	25	32
Std. error	11	21	5.7	5.0	6.2

Strata (feeder AUs)[d]	1	2	3
Barn space			
Mean	21	15	13
Std. error	5.7	3.7	3.5
Shed space			
Mean	22	30	45
Std. error	6.8	8.7	15

[a]N is 11 for each stratum.

[b]Highly significantly different from the means of the three other strata.

[c]Significantly different from the mean of stratum four.

[d]N is 17, 12 and 15 respectively.

have invested more in livestock equipment than necessary.[70]

When the data was stratified according to the proportion of feeders, no differences were found.

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[70] See Table 11, Appendix A for those items of equipment considered.

Table 43. Cash outlay, depreciation, and cash repair expense per animal unit in dollars

Strata (AUs)[a]	1	2	3	4	Pooled
Cash outlay[b]					
Mean	93[c]	57	46	42	60
Std. error	8.9	7.4	13	6.1	5.4
N	11	11	11	10	43
Depreciation					
Mean	4.8[d]	2.9	2.2	1.9	3.0
Std. error	0.57	0.48	0.55	0.26	0.31
N	11	8	8	10	37
Repairs					
Mean	4.4[e]	2.3	2.0	1.9	2.7
Std. error	0.40	0.37	0.38	0.33	0.24
N	11	11	10	11	43

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Corrections applied for old buildings, see Hopkins and Heady, _op_. _cit_., p. 71

[c]Highly significantly different from the means of the other three strata.

[d]Highly significantly different from the means of strata three and four and significantly different from the mean of stratum two.

[e]Highly significantly different from the means of the other three strata.

Miscellaneous Expenses

In Table 44 veterinary expenses are reported separately and include those items of question 40 (Appendix A). The larger operators were expected to spend less per animal unit on veterinary expenses than the smaller operators, and the trend of the data suggested this was the case despite the lack of significant differences between strata means.

Table 44. Veterinary and other miscellaneous expenses per animal unit in dollars

Strata (AUs)[a]	1	2	3	4	Pooled
Veterinary					
Mean	2.7	1.9	1.3	1.1	1.8
Std. error	0.80	0.47	0.30	0.31	0.27
N	11	11	11	10	43
Miscellaneous[b]					
Mean	3.1	2.7	2.8	1.9	2.6
Std. error	0.69	0.49	0.71	0.51	0.31
N	11	8	8	10	37

[a]The number of animal units in each stratum is given in Table 2, page 46.

[b]Includes only costs of: manure removal, concentrate preparation and handling, truck and auto portion, electricity, telephone, magazines, and winter feed for horses (when worked).

Stratification of the data by proportion of feeders did not result in significant differences or visible trends.

Input Data for Regression Analysis

After initial exploration of correlation coefficients between partially aggregated variables, aggregation proceeded by summation which resulted in the following two dependent and six independent variables being defined.

Y_1 denoted the dollar value of beef produced on each farm over a one year period (July 31, 1962 - July 31, 1963) with adjustments for purchases, sales, and inventory changes.

Y_2 denoted the quantity of beef produced in units of 10 pounds and corresponds to Y_1. No weighting procedure was used to account for differing beef mixes on individual farms.

X_1 denoted average number of animal units on each farm during the one year period.

X_2 denoted tons of total digestible nutrients in roughage form consumed by the beef operation--including hay, straw, pasture, and bedding.

X_3 denoted tons of total digestible nutrients in concentrate form with protein supplement converted to grain equivalent.

X_4 denoted hours of labour spent on the beef enterprise on each farm--labour for haying excepted.

X_5 denoted square feet of cattle shelter provided.

X_6 denoted the dollar value of variable costs. It included: the yearly cost of repairs to livestock equipment; buying and selling charges for stock; salt, minerals, vitamins, veterinary charges, and supplies; costs for manure removal; rolling and grinding charges for feed; cattle share of truck and auto expense; winter feed for horses when worked; and telephone and electricity where applicable. Depreciation on livestock buildings and equipment was not included.

Linear equations were calculated using arithmetic and logarithmic values of the variables. Additional equations were calculated after converting the variables to a per animal unit basis by dividing the variables of each farm by the respective number of animal units. The procedure enabled X_1 to be dropped as an independent variable. To retain comparability with preceding analyses, equations using total enterprise and per animal unit data were calculated for each of four strata of size 11, 8, 8, and 10, respectively, for a total usable sample of 37. Statistical values of the variables used in the regression analysis are given in Table 45.

Comparison of the mean square of the residuals was used to select between the linear and Cobb-Douglas functions. Making the measure comparable between functions required that arithmetic values for the residuals of the Cobb-Douglas estimates be calculated. The residuals were calculated by converting the logarithmic estimates to their arithmetic form and subtracting from the observed arithmetic values of the dependent variable.

Table 45. Mean and standard deviation of inputs and outputs of 37 beef operations on a total enterprise and per animal unit basis

Variables	Units	Total Enterprise Mean	Total Enterprise Std. dev.	Per Animal Unit Mean	Per Animal Unit Std. dev.
Value of beef	(dol.)	7756	5073	111	33
Quantity of beef	(10's of lbs.)	3738	2689	51.5	11.2
Animal units	(AUs.)	73	51	-	-
TDN roughage[a]	(tons)	207	133	2.94	0.68
TDN conc.	(tons)	29	32	0.44	0.37
Labour	(hrs.)	1427	726	27	19
Shelter	(sq.ft.)	2862	2311	51	51
Variable costs	(dol.)	1092	825	16	6.6

[a]The variable includes hay, straw, pasture, and bedding.

Limitations of the Data

The writer believes that District Agriculturists probably selected the more outstanding operators for the sample, thus giving an upward bias to the data obtained. The amount of this bias is unknown. Another reason for believing that an upward bias, from a strictly random sample, existed is that management appeared to be on a fairly high level. Viewed broadly, feeding and management practices adopted by the different operators showed a remarkable similarity. The main body of data generated

described the beef operations in the area, but for regression analysis the data suffered from a number of shortcomings.

Original sample size would not allow sufficient stratification to achieve a high degree of homogeneity. Ideally purebred operators should be excluded, and strata organized to include only those who might sell all their calves at weaning or as yearlings. Those who made straw piles available for early winter feed should be excluded or confined to a stratum of their own. If research resources were available, additional strata of herds operated on cultivated land rather than on tracts of native pasture might be studied. A larger sample permitting more rigorous stratification would decrease the possibility of hybrid functions.

Errors within data were characteristic of other than controlled experiments. The beef output variable included beef sold minus beef purchased plus the writer's best estimate of beef produced but unsold during the year (see pages 41 to 42). The roughage variable included roughage assigned to the beef herd and sometimes wasted, plus an estimate of pasture roughage consumed (pages 34, 35, 37 and 38). Doubtless quality of the winter roughage component varied. Quantity of concentrate fed may have been subject to operators memory bias. No adjustment was made for labour quality differences. Small operators spent more time than large operators caring for their animals merely because extra time was available. Theoretically such additional time spent would bear little relationship to beef output. Errors of observation occurred in the shelter variable since bluffs of trees or board windbreaks were often used. The shelter measure used in this study included only the area under roof. Variations of the type described above tended to drive

coefficients of the variables toward zero.[71]

Multicollinearity was a problem with high correlations between the roughage and size variables.[72] High correlations also occurred between the variable cost input and other inputs. Converting the data to the animal unit basis relieved the multicollinearity problem and removed the size variable. One can expect greater confidence in the coefficients generated on the animal unit basis.

Results of Regression Analysis

Inspection of the resulting equations indicated little difference between those calculated using the value of beef or quantity of beef as the dependent variable.[73] Therefore, only equations using quantity of beef as the dependent variable have been included in this study.[74]

Two linear multiple regression equations gave the best fit when all observations for the selected variables in the sample were used. Equations for the pooled data on both a total enterprise and a few animal unit basis were:

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[71] See Johnston, J., Econometric Methods. New York, McGraw-Hill Book Co. Inc. 1960. pp. 148-150.

[72] See Appendix F.

[73] A high correlation exists between these variables. See Appendix F.

[74] A priori one expects the Cobb-Douglas function to provide the better fit to farm enterprise data. In this study, however, use of the criterion of the least mean square of the residuals indicated the simple linear function to be preferable. In only one of the ten data sets compared in Table 48 was the Cobb-Douglas function clearly preferable; in two others it was slightly superior. The linear function has, therefore, been selected for the following discussion.

(1) $Y_1 = -487 + 36.0X_1 + 10.7X_3 + 0.58X_4 + 0.40X_6$

where Y_1 denotes output of beef in 10 pound units; X_1 denotes number of beef animal units per farm; X3 denotes tons of TDN concentrate used by the beef enterprise; X_4 denotes hours of labour spent on the beef enterprise per farm; and X_6 denotes dollars of variable costs used for beef production on each farm.(R^2=95.8).

Dividing the observations on each farm by that farm's number of animal units produced data for which the following equation was calculated.

(2) $Y_2 = 33.4 + 4.32X_2 + 19.1X_3 - 0.11X_4$

where: Y_2 denotes beef output in 10 pound units per animal unit; X_2 denotes tons of TDN roughage in hay, straw, and pasture used per animal unit; X_3 denotes tons of TDN concentrate used per animal unit; and X_4 denotes hours of labour spent per animal unit. The total R^2 was 43.5.

Results from ten linear equations were examined. A combination of different criteria was used in the selection of variables to be retained. Generally variables were deemed unacceptable when their inclusion in the step-wise regression procedure caused the mean square of deviations from regression to increase. Then t-values for the coefficients would fall below 1.0, and the coefficient of multiple determination would indicate little increase in explanatory power.

Using the F-test to compare the mean square of residuals (variances) of the equations calculated for individual strata indicated that efficient estimators may not be expected.[75] Of the twelve possible pairs of variances from the two sets of four strata, three failed at the five percent level and one at the one percent level, indicating that disturb-

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75 Johnston, op. cit., pp. 207-211.

ances within the data did not appear to be independently distributed as required under the assumptions for the normal regression model. While the equations could be used as predictors, comparison of coefficients viewed collectively permitted conclusions that supported the main body of the report.

Table 46. Mean squares of the residuals of ten linear and ten Cobb-Douglas equations using pooled and stratified data from 37 farm beef enterprises on both a total enterprise and per animal unit basis with quantity of beef dependent

Total enterprise

Stratum[a]	N	df.	Mean square of residuals Linear	Cobb-Douglas
1	11	4	128,000*	146,000
2	8	1	850*	11,600
3	8	1	12,200	3,100*
4	10	3	547,000*	838,000
Pooled	37	30	361,000*	678,000

Per animal unit

Stratum[a]	N	df.	Linear	Cobb-Douglas
1	11	5	158*	167
2	8	2	100	75*
3	8	2	1.2	22
4	10	4	47	45*
Pooled	37	31	82*	94

[a]The number of animal units in each stratum is given in Table 2, page 46.

*Least mean squares of the residuals.

Conclusions Table 47 reports in value terms the contribution to beef output made by the various inputs. To obtain the output section of Table 47, the coefficients of the ten equations were multiplied by $20.80 per hundredweight, which was the average value of the beef mix produced on the sample farms.

The cost of carrying an additional animal unit (X_1 in Table 47) was dependent upon the interest rate assumed. A charge of fifteen percent resulted in \$32; seven percent would result in only \$15. Budget studies covering the period 1946-1962 by the Department of Agricultural Economics, University of Alberta indicated that fifteen percent, rather than a market rate of interest, would be a more realistic figure for a farmer's return on his livestock investment. Under the price assumptions used in Table 47, an input of \$32 would result in outputs of \$147, \$220, \$86--for the pooled data, \$75. One could conclude that operators in the area should increase the number of animals in their beef enterprise. As noted previously, this was being done, often as rapidly as possible without buying heifers. The regressions did suggest that small operators (those in strata one and two) would have had most to gain by increasing their herd numbers. However, numbers, if increased, should not have been accompanied by proportional increases in other inputs.

No clear conclusions could be drawn concerning roughage use. One significant coefficient in the pooled data on the per animal unit basis suggested an excessive use of roughage. Other assumptions could be made regarding the input value of a ton of TDN roughage. If roughage production were treated as necessary for proper soil management, it might have been charged at something like \$15 per ton of TDN roughage or even less.[76] Roughage use may have been consistent with the lower price.

Both coefficients for the pooled data indicated that farmers were using more grain concentrate than was profitable. The conclusion was

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[76] See footnote d, Table 49.

Table 47. Contribution to beef output in dollars as predicted by 10 linear equations for 37 Peace River beef enterprises[a]

Input: Value or size		Output: Stratum[b] 1	2	3	4	Pooled
Total enterprise						
X_1	$32[c]	147	220	ns[d]	86	75
X_2	$25[e]	ns	3.62	47.60	-29.80	ns
X_3	$47[f]	21.10	-43.00	81.00	48.00	22.30
X_4	1 hr.[g]	ns	-0.57	ns	1.10	1.20
X_5	1 sq.ft.[h]	ns	0.23	0.31	-0.51	ns
X_6	$1[i]	ns	2.46	-5.40	0.88	0.83
Per animal unit						
X_2	$25	9.10	ns	43.00	ns	9.00
X_3	$47	22.80	ns	70.00	29.00	39.80
X_4	1 hr.	-0.85	ns	0.23	1.70	-0.23
X_5	1 sq.ft.	ns	ns	0.27	-0.50	ns
X_6	$1	ns	2.80	-4.95	ns	ns

[a]The two equations for the pooled data are presented in Appendix F.

[b]Description of the strata is given in Tables 2 and 46.

[c]The yearly cost of adding an additional animal unit was estimated to be $32. The average herd (Table 10) was composed of 81% breeding herd and 19% feeders on an animal unit basis. With an animal unit of breeding herd worth say $210, 81% of $210 was $170. An investment of $170 at 15% was $25.50 per year. Interest on 19% of an animal unit of feeder stock worth $240 was about $7. Depreciation on breeding stock was not an input under the definitions of the variables used in this study.

[d]Regression coefficient was not sufficient.

[e]The value of one ton of TDN in roughage form was calculated using prices given in Appendix E. Prices per ton were weighted by the mean proportions of the four roughage classes used for each livestock class (Table 27). The resulting weighted price per ton of roughage going to each livestock class was converted to a price per ton of TDN using the proportion of TDN as 48% in a ton of roughage. Multiplying the price per ton of TDN going to each livestock class by the average number of tons used by the average animal in each class (Tables 28-32) gave the value of TDN winter roughage fed each animal. This figure was then weighted by the proportion of animals in the average herd to give $29 per ton of TDN for winter roughage. Each animal unit obtained 2.84 tons

TDN roughage over the year (Table 45). Pasture provided 43% of this or 1.22 tons (from unreported data) over a period of 181 days (Table 1). Arbitrarily selecting $4 per month (Appendix E) enabled assigning a cost of 181/31 x 4/1.22 = $19 per ton TDN for pasture roughage. Weighting $29 by 57% and $19 by 43% gave about $25 for a one-unit input of TDN roughage.

[f]The price of one ton of TDN in concentrate form was calculated in a manner similar to that for roughage using data in Tables 6, 33 and 35.

[g]Assigning a value of $1 per hour of labour has been common practice.

[h]The cost of materials to provide one square foot of shelter was about $0.85.

[i]No calculation was required as the input (variable costs) was already in dollars.

supported by feeding standards which indicated that operators were too generous in their grain allowances to breeding stock. For labour, shelter, and variable costs, no tentative conclusions could be drawn, for often the coefficients were not significant.

In summary, regression analysis indicated that farmers could increase profits by either increasing their herd size <u>or</u> by decreasing concentrate inputs while other inputs remained constant. Per animal unit data supported the same conclusion; it indicated that too much concentrate was being fed per animal unit meaning that concentrate could be held constant while herd size was increased. Too much concentrate would appear to have been fed for the number of cattle being kept. The use of roughage in its aggregate form may either be over-used or in equilibrium. The data did not permit conclusions to be drawn concerning labour, shelter, and variable cost inputs.

SUMMARY

The study was directed toward obtaining physical input-output information on beef breeding enterprises in the Peace River area of Alberta suitable for use in budget analyses and linear programming procedures.

Information was collected over the one year period July 31, 1962, to July 31, 1963, on 45 enterprises having from 10 to 225 breeding females. Of primary interest was whether operators of small breeding enterprises organized their resources differently than did those operating on a larger scale. Demonstrable differences would allow refinement in the application of budgeting tools to farm planning in the Peace River area.

The 45 farms were divided into four strata based on size; the size measure was the average number of beef animal units kept on the farm during the survey year. The data was also arranged in three strata based on the proportion of feeder animal units to total beef animal units. The latter stratification was necessary to study resource use patterns since operators commonly kept their calves for varying lengths of time after weaning. (Only seven operators sold their calf crop at weaning age.) The search for differences between strata employed the t-test on strata means. In addition, regression analysis applied to the data gave evidence for some conclusions regarding resource imbalance.

In addition to information on land, labour, and capital resources used for beef production, statistics were obtained on management factors involving items such as calf crops, livestock losses, culling and replacement rates, cow-bull ratios, breeding practices, and roughage handling. Differences that were observed between strata are outlined in the following paragraphs.

The hypothesis that smaller operators would feed more roughage to cows and heifers than larger operators was rejected; a statistically significant difference was found with regard to use of concentrates for the same livestock class. The smallest operators (stratum one) fed the greatest quantity of concentrate to all classes of stock except bulls. The observation that the generous concentrate allowance was not extended to bulls was partially accounted for by the fact that as herd size increased, bulls on the sample farms were confined for a progressively longer period. Differences between strata for the length of time bulls were with cows were not statistically significant, but the trend was evident. A larger sample would surely demonstrate superiority in this aspect of management for the larger operators. On the average comparison with feeding standards suggested that excessive concentrate was fed by the average operator to cows, heifers, bulls,and replacement calves. Very few operators separated replacement heifer calves from those calves being fed for market hence the replacements received too liberal a concentrate allowance. Supplementation with minerals and vitamin A was satisfactory on the average, but financial benefits could have been derived by increasing the use of protein supplements.

Smaller operators appeared to use a larger proportion of greenfeed hay in the roughage ration than do the larger operators. This observation was supported by land use patterns. The smallest operators used significantly more acres of land for greenfeed production per animal unit than do the operators in other strata. The small operators also depended more heavily upon their cultivated acres for winter feed and pasture production than did the larger operators. Often larger operators had access to native pasture land while small operators did not.

Seven out of the eight operators who did not breed yearling heifers were in strata one and two, indicating that small operators were the most hesitant to breed yearling heifers.

As herd size increased, less labour, less investment in livestock equipment, and less livestock shelter was used per animal unit. The fact that small operators used more labour and livestock equipment per animal unit may be an unavoidable consequence of scale.

An original hypothesis was that the larger operators would be the most efficient with regard to beef output measures. On the basis of this sample there was insufficient evidence to accept this hypothesis. Trends within the data suggested: (1) that the smaller operators may have achieved more pounds of beef per animal unit, and (2) that this increased production resulted from using more feed for each 100 pounds of beef produced. Lack of statistical significance in both these trends left the question of efficiency unresolved as far as these two measures are concerned. As expected, when the proportion of feeder animal units in the enterprise increased, more beef was produced per animal unit, and less feed was required for each 100 pounds of product.

Least-squares regression equations were fitted to the data using arithmetic and logarithmic values of the variables. Using the criterion of the least mean squares of the residuals, the linear equations were found most appropriate. Thus within the size range of operations studied decreasing returns to scale were not in evidence.

Examination of marginal costs and the expected returns as predicted by these equations (after applying factor costs) supported a number of the preceding conclusions. Decreasing concentrate allowances that increased profits were of particular interest, and roughage allowances may be in

equilibrium with the beef-roughage price ratio. Comparing roughage consumption against the feeding standards presented by Morrison's Feeds and Feeding and the National Research Council found sample farm roughage allowances high. However, when consideration was given to operator comments concerning the poor quality of their roughage for the winter of 1962-63, roughage use appeared reasonable.

Regression analysis suggested too that herd size could profitably be increased, especially in strata one and two which were composed of the smaller operators. The operators surveyed had found their beef enterprise profitable and over the previous three years had expanded the number of breeding females in their enterprise by 48 percent. A further increase of 17 percent was planned for the following three years.

Important trends and significant differences among strata other than those reported did not occur. The differences which were found seemed sufficient to conclude that small operations did employ different resource patterns than large operations and that larger operators were applying their management more skillfully. Knowledge of appropriate differences to be expected between different sized operations will enable refinements to be made in formulating livestock budgets.

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69. Pond, G.A. and Hasbargen, P.R. Progress Report on N.C. 28 Regional Project. Univ. Minn. Multilithed report. (Circa 1957).

70. Costs of Production in Agriculture, 1962. (A Summary of Selected Studies Conducted in Recent Years by Various Agencies). Ottawa. Econ. Div. Can. Dept. Agr. Multilithed Rpt. May, 1963.

71. Proceedings of the Peace River Agricultural Coordinating Conference. Sponsored by the Peace River Branch of the Alberta and British Columbia Institute of Agrologists and the Agricultural Institute of Canada. Beaverlodge, Alberta. Multilithed report. Jan. 12-13, 1963.

APPENDIX A

Designing the Questionnaire

The investigator prepared the questionnaire. This questionnaire was used for personal interviews with practicing operators to obtain data which form the basis of the study.

The Edmonton Office of the Economics Division of the Canada Department of Agriculture kindly made available samples of the completed questionnaire that they had used in a ranch survey conducted in 1962. Though different in intent, the sections on physical data served both as a model and as an illustration of a number of difficulties. Accordingly, modification and additions were made to those sections applicable to this study. An attempt was made in formulating questions to benefit from suggestions given by those experienced in questionnaire design.[77] Questions were arranged in order of importance of information desired with the exception of the first two introductory questions, at the same time striving for logical recall of information from the respondent for each section.

A pretest was arranged with five south Alberta ranch operators,

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77 Payne, Stanley L., The Art of Asking Questions. Princeton N.J., Princeton University Press. 1951.

and criticisms and suggestions were sought from several livestock research personnel in the Province.[78] On the basis of difficulties encountered and suggestions received, the revised questionnaire as presented in Appendix A was derived and used.[79]

Selecting the Sample

The area studied lay within the area bounded by Township 68 to the south, Manning to the north, Kinuso to the east, and west to the Alberta British Columbia border. Considerable effect would be required to define the population of beef breeding enterprises within these boundaries, and accurate information on number and scale of beef enterprises in the area was available.

The Alberta Department of Agriculture divided the settled agricultural area of the Peace River region into four somewhat equal districts with an extension office serving each. Consequently, each district agriculturist was requested to furnish addresses and size estimates of beef breeding operations in his district. Each of the

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78 Pretesting in the area to be studied would have been desirable, but it was a matter of convenience and possibly advantageous to pretest in the area in which several livestock researchers could also be consulted.

79 The final questionnaire also suffered from a number of shortcomings. Desirable improvements are suggested in Appendix A.

four district agriculturists was told that an initial list of at least 120 beef cow herd operators was desired i.e. 30 or more from each district extension. For size of operation estimates the district agriculturists were asked to place each operator name in one of three strata on the basis of number of beef breeding cows handled. Initial strata selected were 0 to 53 cows, 54 to 90 cows, and 91 cows and above. In addition, agriculturists were asked to provide as many names as possible of those operators in the two size strata.

The lists received contained the names of only 13 operators who were estimated to own 91 cows or more. All in this stratum were selected for interview on the theory that they would be more knowledgeable and provide more accurate information than on equal number of producers with very small beef enterprises. The 13 operators constituted stratum three in this study.

Stratum two included a sample selected at random from the names of operators 30 estimated to have 54 to 90 cows.

Stratum one constituted a random sample selected from 45 owners who were estimated to have 0 to 53 cows.

In deciding upon the number of operators to be selected from strata one and two, consideration was given to:
(1) providing a sufficiently large sample over-all to lend reliability to the statistics, (2) providing approximately equal numbers in each strata, (3) retaining a degree of proportionality between numbers selected and numbers provided, (4) the research resources available. See Table 48.

Table 48. Procedure for drawing the sample of beef operators in the Peace River area on the basis of incomplete census data furnished by district agriculturists in four districts.

Stratum	Grand Prairie	Spirit River	Berwyn	High Prairie	Total Provided	Total Selected
Stratum 1						
(35.5% selected)						
Number provided	10	8	22	5	45	
Number selected	4	3	8	2		17
Percent of total provided					(51)	
Percent of total selected						(38)
Stratum 2						
(50% selected)						
Number provided	7	11	5	7	30	
Number selected	3	5	3	4		15
Percent of total provided					(34)	
Percent of total selected						(33)
Stratum 3						
(100% selected)	4	5	1	3	13	13
Percent of total					(15)	(29)
Total					88	45
Total (percent)					(100)	(100)

On the expectation that a number of the operators selected would not cooperate, provision was made to select at random additional operators

within size strata to substitute for the non-cooperators and thereby retain the planned sample size. However, randomness in this respect was not completely achieved. Whenever a non-cooperator was encountered various practical difficulties arose which resulted in selecting the substitute on grounds of availability rather than randomness. Practical difficulties which interacted were: (1) very few operators had telephones, (2) postal service and personal mail pickup by farmers was slow, (3) attempting to enlist cooperation without introductory letters resulted in losing what might otherwise have been a cooperator, (4) a random selection often resulted in long driving distances and conflict with appointments made with other operators, (5) muddy roads delayed contact. However, since only four substitutions were made, perhaps little adverse effect resulted.

Sample Characteristics

Results of the interviews revealed that initial stratification according to size groups by the district agriculturists was imprecise. There were actually fewer operators in strata two and three than expected, hence stratum one was considerably enlarged. Table 49 gives the changes that occurred along with subjective estimates of the population of beef enterprises in the Peace River Region. District agriculturists seemed to have selected those operators who were successful managers. A large proportion of those operators interviewed had access to river breaks and if not to river breaks to extensive tracts of lease land.

Whether their success came from their fortuitous land right acquisition which resulted in their being selected by district agriculturists remains uncertain.

One possible source of sample heterogeneity resulted from the discovery during interviews that eight operators had pure-bred cattle as a part of their beef production plan. The difficulties of locating and interviewing replacement operators, and strong indications that inputs and also outputs did not differ greatly from commercial operators caused retention of their data in the study.

Table 49. Numbers of beef operators sampled within strata and population estimates, Peace River area, 1963.

Breeding Cows	Stratum 1 0-53	Stratum 2 54-90	Stratum 3 91+	Total
Estimated number in sample (farms)	17	15	13	45
Number actually sampled (farms)	23	11	11	45
Number marketed (animals)[a]	590	530	1020	2140
Estimated number of operations (farms)[b]	900	44	13	957

[a]Indicates that the 23 farms in stratum 1 marketed 590 beef animals in one year.

[b]Subjective estimates, figures significant to one place only. In conversations with cooperators the author believes that all but 2 or 3 of those operators in stratum 3 were interviewed and perhaps one-fourth of those operators in stratum 2. Using Fetherstonaugh's estimates (op.cit.) of 26,000 beef animals marketed in 1963 from the Peace region and using the previous two estimates for strata 2 and 3, perhaps 23,000 were marketed by the small operators. If an average of 26 animals were sold per farm in stratum 1, then approximately 900 farms would be required to produce 23,000 cattle.

QUESTIONNAIRE, JULY 31, 1963

Name:____________________

Address:____________________

Legal Description____________________

Date Taken____________________

County or M.D.____________________

1. Give the name of the market where you sell the majority of the following classes of cattle:

   (a) Calves and yearlings__________ _______________
   name distance in miles

   (b) Cull cows and cull bulls ________ _______________
   name distance in miles

2. (a) Have cow numbers in your herd increased, remained constant or decreased in the past three years? __________

   ____

   How big has the change been? Describe.

   ____

   ____

   (b) Do you plan to change your cowherd numbers in the next three years? ________ ________
   yes no

   If yes, how much? __________ __________
   increase decrease

(Questions for Table 1)

3. How many breeding females do you have in with your bulls this summer? (Fill in Table 1 and divide into classes).

4. How many calves will you be weaning this fall?

   ____________________(Box 12b)

5. How many calves did you wean last fall?

   ____________________(Box 12a)

6. Of the calves you produce what percent do you sell at weaning age? ______ What percent do you sell as yearlings? ________ What percent as two year olds? _______

7. Of the calves wintered last winter,how many died?

   ____________________ (Fill in deaths of the classes over the past year).

WINTER FEEDING

8. (a) How many tons of roughage did you have on hand last fall? ____

   (b) How many tons did you have left this spring?_______

   (c) Did all roughage fed go to the cowherd?____________

   If no, explain ____________________________________

9. Would you consider last year to be a normal feeding year?____

   If no, what quantities of roughage would usually be fed in a winter to a herd of your present size? _______________

   ____

Table 1. Cattle numbers

Class	No. July 31 last yr.	Calves weaned last fall	Losses Death Theft etc.	Home Used	No. July this yr.	Claves wean this fall	Ave. Wt. to Summer grass	Ave. wt. off grass
Calves		12a	*			12b	X	X
Breeding females	X	X	X	X	X	X	X	X
Yearling heifers		X				X	X	X
2 yr. olds		X				X	X	X
Mature cows (3 yr.olds inc.)	..	X				X		
Total		X				X	X	X
Bulls breeding		X				X	X	X
Bulls non-breeding		X				X	X	X
Yearling heifers (non-breeding)		X				X	X	X
1 yr. old steers		X				X	X	X
2 yr. old steers		X				X	X	X

*Winter losses of calves after weaning

Table 2. Cattle Sales July 31 - July 31.

	No.	Age	Date	Total Weight	Total Receipts	Office Use Unit Weight	Office Use Unit Price
Feeders							
Calves heifers							
Calves steers							
Yearling steers							
Yearling heifers							
Breeding cows							
Slaughter cows							
Breeding heifers							
2 yr. old steers							
2 yr. old heifers							
Bulls breeding							
Bulls slaughter							
Fat cattle sales							

Table 3. Livestock purchases July 31 - July 31

	No.	Date	Total Weight	Total Cost	Office Use	
					Unit Weight	Unit Cost
Breeding cows						
Breeding heifers						
Bulls						
Feeder cows						
Feeder heifers						
Feeder steers						
Feeder calves						

10. How many animals did you winter last year? (Let's begin with the number of cows wintered).

<u>Fill in Table 4.</u>

Table 4. Winter feeding number

	Cows (Inc. 2 yr. old heifers)	Long yearling heifers	Bulls	Calves		Long yearling steers
				Steers	Heifers	
Last winter						
Winter before last						

Table 5. Winter Feeding - Quantities

(For calves collect quantities of all feed fed from weaning to spring)

	Cows incl. 2 yr. old heifers	Heifers long yearling	Bulls	Calves	Steers long yearling
Roughage Fed From-to					
Legume					
Tame Grass					
Native					
Greenfeed					
Straw					
Other					
Grain Fed From-to					
Wheat					
Oats					
Barley					
Other					
Protein Supplement - Describe - Protein percent and vitamin content					
Bedding					

11. (a) Which dates on the average do you begin and quit winter feeding cows? ________________

to ________________

Table 6. Feeds - Prices and Weights

Grain		Hay			
	Prices/bu.		Prices/T	Bale Wts.	Fraction of Total
Wheat	______	Legume	______	______	______
Oats	______	Tame grass	______	______	______
Barley	______	Native	______	______	______
Rye	______	Cereal hay	______	______	______
Other (Desc)	______	Other (Desc)	______	______	______
			Bedding	______	______

16. How do you manage the replacement <u>yearling</u> heifers during spring and summer?

    (Different pastures - must if not bred)

    (Better pastures? - describe)

    (Different bulls? - describe if bred)

    (Grain fed? - quantities)

17. During the spring and summer are the two-year-old heifers kept separated from the mature cows? ______________________

    If yes, why are they separated? ______________________

    ____

    ____

18. Would heifers having their first calf be given special attention?

    If yes, describe. ______________________

    ____

CULLING

19. Is culling an annual a semi-annual or monthly process?

_______________ (dates) _______________

Describe the culling procedure you use for the cowherd?

____

____

____

____

____

- pregnancy test?
- give young cows another chance? - what age?
- cull all dry cows?
- cull all over a certain age? - what age?
- cull heifers that didn't produce a calf? (refer to question 24).

20. (a) How many cows do you usually cull each year? _______________

(b) How many of these cows would be culled because they are disabled? _______________ (bad udders, cancer eye, prolapse, crippled).

21. (a) (If pregnancy tests) What is your procedure for these non-pregnant cows? Do you sell off grass in the fall? _______________ yes _______________ no

(b) If yes, at what month do you usually sell? _______________

(c) What do these cull cows weigh? _______________

(d) (If no to 21a) Then how do you handle the non-pregnant cows? _______________

22. (a) What month do you sell the cull cows? ____________________

(b) What do the cull cows weight at date of sale? ______________

____

23. At what age do you select replacement heifers? ______________

24. How many replacement heifers do you normally hold back each year? ____. (If this number is significantly greater than the answer to question 20a, ask for explanation).

25. Describe your replacement procedure for bulls?

- keep 2 yrs. and sell?

- keep till breakdown?

26. In which month do you ordinarily sell cull bulls? ______________ ________________. What is the usual sale weight of cull bulls? ______________________________. What price can you expect for the cull bulls? ____

27. (Consider all reasons for culling, including accidents, sickness, impotency, age, and inbreeding on own daughters). On the average how many years would you say a bull can be used in your herd?________.

28. At what date do you usually turn your bulls in with the cows? ________________________________ ..take them out? ______________ ____

29. During what period are most of the calves born? ______________ ____________________________ to ______________________________

30. (a) How far would you be willing to move your cowherd to summer pasture? ____

(b) Is it possible to rent additional pasture within this

distance from headquarters? ____________ ____________
yes no

(c) (If yes) What is the going rate for pasture rental in

this area? (For a cow and her calf) ____________________

____________________________- for yearling stock _____

____

31. (If no - not possible to rent pasture)

What do you think a fair rental rate for pasture would be if

pasture were available for rent? ____________________________

____

32. (a) How many acres of land do you operate? (Owned, rented and

leased) ____

(b) Has the acreage you operate changed in the past year?

__________________ ____________________
yes no

(If so) Please give the date ____________________________

acreage ____

Of this change in acreage how much was:

(a) native pasture ______________________________________

(b) tame pasture ____

(c) regular cropland ____________________________________

(d) Government lease ____________________________________

Total ____

33. (a) How much is (or has been) cultivated? __________________

(b) What is your best estimate of the market value of your

cultivated land? ____________________________________

(c) Of the cultivated acreage, how many acres are in:

Mixture Used

tame hay ______________________

tame pasture ______________________

forage seed crops ______________________

(d) How many acres are cut for hay? ______________________

(e) How many acres are usually cut for greenfeed? ______________________

____

(f) How many acres are planted to cover crop each year?

____

(g) How many acres of wheat, oats and barley are normally harvested for grain every year? ______________________

- acreage of other crops usually grown? (describe)

____

- acreage of summer fallow? ______________________

______________________Total ______________________

34. (a) How many acres have never been cultivated? ______________________

____

(b) How many acres of this land are cut for hay? ______________________

(frequency of haying) ______________________

Table 7. Land use unimproved

Description - brush cover in percent	Acres	Market Value
Native Pasture (River Breaks)		
Native Pasture (Aspen Cover)		
Native Pasture (Other)		
Muskey		
Swamp		
Lakes		

35. Describe how you pasture the land you operate? (For example, during what periods of the year are your cows on native rante, river breaks, stubble fields, muskey, etc.?)

Table 8. Periods of pasture use

Description	From - to
Native pasture - river breaks	
Native pasture - aspen cover	
Native pasture - other	
Muskey and swamp	
Tame pasture	
Stubble fields - forage seed crop - grain	

36. Do you rotate tame hay and pasture crops over your cultivated acreage? ______________ yes ______________ no

37. Describe the (cropping system) (rotation) you use.

- sequence? ______________________________
____

- How long is tame hay and pasture left down? ______________
____

- Which crops in this sequence receive fertilizer? (refer to Table 9)

Table 9. Fertilizer use

	When Applied	Analysis	Lbs./acre
Wheat			
Oats			
Barley			
Other (Desc)			
Tame Hay			
Tame Pasture			
Forage seed crops			
Native			

38. (a) How many tons of hay and greenfeed did you put up last year? ______

(b) What kind of haying equipment do you use? (check)

Hayrack	Tractor or Auto Sweep
Pitch	Pole Stacker
Rack loader	Sweep Rake and Stacker
Hay Fork Carrier	Hay Conditioner
Field Forage Harvester	Pickup Baler with trailers
Swather	with barge
Other (desc)	

39. (a) How much salt did you use for the cowherd last year? ______

(b) How much bonemeal did you use for the cowherd last year? ______

______

(c) - other phosphorus supplements, describe, quantity?

______

(d) Did you use limestone ($CaCO_3$) last year? quantity?

______

40. How much did you spend on:

Vaccines ______

Medicines ______

Antibiotics (for cowherd) ______

Vitamins (aside from that fed in range rations) ______

Sprays and dips ______

Livestock insurance ______

Veterinarian's charges for cowherd ______

Total ______

Table 10. Labour

Operation	Periods Worked	No. of Men	No. of Days Worked	Length of Days Worked	Office Total Hours
Haying (2 or more periods)					
Baling straw					
Baling bedding					
Winter feeding					
Calving					
Repair of corrals, fences, troughs & other cowherd equipment					
Branding, dehorning, vaccinating, castrating					
Moving and separating					
Hauling					
Salting, inspection & supervision of cattle					
Selling and buying					
Manure removal					

41. (a) What kind of facilities do you have for watering cattle?

(describe) ______________________________

wells - depth?

dugouts

kind of pumps

frost protection

winter operation

(b) Are these facilities adequate for both winter and summer?

(If no) Explain. ______________________________

____

(c) Could greater use be made of pasture if more water were available? Explain. ______________________________

____

42. How many tons of hay do you store under shelter? ______________

Table 11. Description of shelter and equipment for the cowherd.

Description	No.	Size	Age or Yr.Acq.	Orig. cost when acq.	Pres. Value or Fair Mkt.	Annual cash expense (Repairs Replcmt. Ins.)	
Barns							
Sheds							
Windbreaks							
Corrals							
Chutes							

Table 11 continued

Description	No.	Size	Age or Yr. Acq.	Orig. cost when acq.	Pres. Value or Fair Mkt.	Annual cash expense (Repairs Replcmt. Ins.)	
Granaries (for cowherd only)							
Silos							
Hay shelter (plastic)							
Feed troughs							
Mineral troughs							
Water troughs							
Wells							
Windmills							
Dugouts							
Pumps & motors (pump instal. & housing)							
Pipes & hoses (installation)							
Tank heaters							
Automatic stock waterers							

Table 11 continued

Description	No.	Size	Age or Yr.Acq.	Orig. cost when acq.	Pres. Value or Fair Mkt.	Annual cash expense (Repairs Replcmt. Ins.)	
Horses							
Saddles							
Ropes							
Spray equip-ment							
Calf puller							
Irons							
Torches							
Syringes							
Hoof trimmers							
Forks, shovels							

43. Have you changed your beef production practices during the past three years? ____________. (If yes, explain) ____________

____

44. What changes are you planning to make in your beef production practices in the next two or three years? ____________

____

Weaknesses were encountered in the above questionnaire, and a number of improvements would be warranted.

Rather than collecting livestock sales data in the form of Table 2, a preferable procedure would be to duplicate the operator's sales and purchase records and have him identify the animals on these records as to age and origin. This information could then be handled in the office and converted to a form such as in Table 2.

Questions eight and nine would best be handled in tabular form with columns for: roughage on hand, used, carried over, and normal use. Rows would designate roughage kinds and bedding. Bale weights and prices would also best be collected at this time. Perhaps an operator estimate of roughage quality would be useful.

In the collection of acreage figures the proper procedure would be to designate the acreage in various usages at interview time and balance the figures using some tabular form. If information were required on normal acreage use, it should be collected after the present use patter had been defined.

Possibly a much expanded form of Table 1 would be better for field work. Such a form would have rows as in Table 1 but would have a wide column for every month of the year under survey. Sales, purchases, and deaths could be placed on such a form as they occurred. The form could easily accommodate additional information on weights, prices, and periods on and off pasture. The author believes the use of such a form would greatly facilitate the balancing of cattle numbers at interview time, for such a sheet becomes an easily interpreted flow diagram.

A weighting system for different animal classes may take into consideration one or all or any combination of factors such as size of animals, consumption of one or several inputs, or other characteristic that may assume importance.

In this study weighting by input consumption was appropriate. No system was completely satisfactory because constant proportions of inputs did not exist for the different beef classes. One alternative was to select one or two of the most important inputs important in the sense that they constituted a large proportion of the expense of production and accept distortion between classes for the remaining inputs. Feed was the major input in beef production, and TDN was the most practical weighting measure that had been devised for the major feedstuffs. Both NRC and Morrison standards gave recommendations in TDN.

Given the assumption that weighting should be by feed intake, the examination of different problems would dictate that weighting coefficients vary from case to case. If, for example, the problem were concerned with grazing rates, then animal classes should be weighted according to their respective quantitative consumption of forage over the period being examined. Weighting coefficients to convert animals to animal units for a wintering period would be different since cows were on maintenance, and not milking, and yearlings were likely being fed a fattening ration. Since feed requirements differed from season to season it was proposed that weighting coefficients be designed to reflect seasonal changes when examining a farm beef enterprise over a full year. Followed to a conclusion, the above proposal suggests each region or farm stratum

should use its own unique set of weighting coefficients, suggesting too a possible reason for differences in the various coefficients used.*

Table 50 presents tentative suggestions for coefficients for the grazing season. The latest NRC data gave 16.8 pounds TDN daily as the requirements for nursing cows three to four months postpartum. Since the calf can be considered inseparable from the cow until weaning, this figure was used throughout the grazing season, and calves were ignored. If the TDN consumption figures were realistic, the three different sets of weighting coefficients differed appreciably from those in current us. Coefficient set two differed from set one in that an assumption concerning dry cows is made, reducing the daily TDN intake for the average cow in the field. Coefficient set three used an estimate of a defined animal unit intake on pasture (see Table 50, footnote d) and raised the coefficients for yearlings and two-year-olds so that they compare with those of other workers.

A similar table could be constructed using Morrison's allowances in which nursing cows were to get 13.2 pounds TDN, and bulls (dairy heavy service 1400 pounds used as estimate) were to get 11.6 pounds TDN. Coeffieients corresponding to coefficient set two in Table 50 would then be 1, 0.76. 0.77, 0.80, and 0.88.

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* For the various coefficients used see: McNary, op. cit.; Acton and Woodward, op. cit.; Range, Its Nature and Use. Lands Br. Alta. Dept. Lands and Forests, Ext. Br. Alta. Dept. Agr. Pub. 146. 1960; Johnston, A., Leth, Expt. Stn. Private Communication, 1963, gave; cow, 1 AU; bull, 1.25; 2 yr. old, 0.8; yearling, 0.6; in reference to grazing.

Table 50. Daily nutrient requirements and weighting coefficients for computing animal units during grazing season

Livestock Class	TDN[a]	Coefficient 1[b]	Coefficient 2[c]	Coefficient 3[d]
Nursing cow	16.8	1	1	1.27
Dry cow	10.0[e]	0.59		0.76
Yearling 670-850 lbs.	9.5[f]	0.57	0.61	0.72
2 yr. old 1000 lbs.	10.0[g]	0.59	0.65	0.76
Bull 1400 lbs.	14.0	0.83	0.91	1.06

[a]Based on NRC recommendations except where noted.

[b]Calculated using 16.8 as denominator.

[c]Calculated using 15.5 as denominator which is a combination of daily seasonal TDN requirements of nursing and dry cows under the assumption that 20 percent of the cows are not raising calves.

[d]Calculated using 13.2 lbs. TDN as a basic animal unit. See Campbell, et al. Range Management of Grasslands and Adjacent Parklands in the Prairie Provinces. Can. Dept. Agr. Pub. 1113. 1962. p. 14, wherein 22 lbs. of air-dried grass is given as the consumption of a basic animal unit. Assuming mostly young plants being consumed thereby containing 60 percent TDN on air dry basis this 22 lbs. would give 13.2 lbs. TDN (Of note is that 13.2 is midway in the TDN allowance for nursing cows as given by Morrison, 22nd ed.).

[e]Author's estimate.

[f]Normal growth as given by NRC.

[g]Author's estimate.

For the wintering period calves must now be included. Yearlings were heavier in weight, and cows were being fed to maintain reproductive capacity. Table 51 illustrates the way in which coefficients change under these circumstances.

Table 51. Daily nutrient requirements and weighting coefficients for computing animal units during wintering period

Livestock Class	TDN[a]	Coefficient[b]
Cow (in calf) 1000 lbs.	9.0	1
Yearling 800 - 950 lbs.[c]	10.0	1.1
Calf 400 - 650 lbs.[c]	7.0	0.78
Bull 1400 lbs.	14.0	1.6

[a]Based on NRC requirements.

[b]Calculated using 9.0 as denominator.

[c]Fed for normal growth, (NRC). (See main text for feeding practices in Peace River area.)

Combining the data in Table 50 and 51 and assuming for simplicity both a six month grazing and wintering period, coefficients applicable to problems involving a full year period could be derived. (See Table 52)

Table 52. Estimated yearly average TDN requirements per day and coefficients for computing animal units over one year.

Livestock Class	TDN[a]	Coefficient[b]	$\frac{1}{\text{Coefficient}}$
Cow 1000 lbs.	12.2[c]	1	1
Yearling 670 - 950 lbs.	9.8	0.80	1.25
2 yr. old 1000 lbs.	10.0[d]	0.82	1.22
Calf 400 - 650 lbs.	7.0	0.57	1.75
Bull 1400 lbs.	14.0	1.15	0.87

[a]Based on NRC requirements.

[b]Calculated using 12.2 as denominator.

[c]Calculated using assumption of 20 percent dry cows during pasture period, and daily TDN consumption during grazing period and wintering period each weighted by six months.

[d]Author's estimate.

Comparison of either the coefficients or their reciprocals with those commonly used showed a large discrepancy. The TDN figures used in the tables were subject to revision but were nevertheless based on the latest recommendations. If animal unit coefficients pretend to be based on feed consumption, a thorough examination is warranted.

APPENDIX C

Table 53. Grain weights in pounds for two container sizes and three states of preparation for wheat, oats, and barley[a]

	Oats	Barley	Wheat
Whole			
1 gal.[b]	5.32 (5.80)	6.00 (6.55)	7.61 (8.30)
5 gal.[c]	28.6 (31.0)	30.9 (33.5)	40.1 (43.5)
Ground[d]			
1 gal.	4.17 (4.55)	4.86 (5.30)	6.69 (7.30)
5 gal.	20.7 (22.5)	25.4 (27.5)	36.0 (39.0
Rolled			
1 gal.	3.21 (3.50)	3.90 (4.25)	-
5 gal.	16.8 (18.2)	21.0 (22.8)	-

[a]In all cases contents slightly settled.

[b]One gallon cans filled to within 3/4 inch of top. Cans nine inches high. Full weight of contents in brackets.

[c]Five gallon cans filled to within 1 1/4 inches of top. Cans 16 inches high. Full weight in brackets.

[d]Coarse grind.

APPENDIX D

Table 54. Monthly labour expenditures per animal unit in hours*

Month	Mean	Std. error	Month	Mean	Std. error
Jan.	2.6	0.36	July	4.9	0.55
Feb.	2.7	0.39	August	2.4	0.32
March	3.2	0.55	Sept.	2.5	0.40
April	3.7	0.40	Oct.	2.4	0.28
May	3.6	0.39	Nov.	3.0	0.36
June	1.7	0.24	Dec.	2.6	0.37

Table 55. Labour expenditure per animal unit in hours for job categories*

Category	Mean	Std. error
Haying	8.6	0.69
Winter feeding	17.7	2.6
Calving	1.7	0.27
Fence repair	1.6	0.16
Repair cowherd equipment	1.1	0.15
Brand, dehorn, vaccinate	0.44	0.05
Moving and handling cattle	0.89	0.12
Hauling, buying, selling	1.02	0.21
Salting and inspection	1.4	0.33
Manure removal	1.2	0.19

*N is 39 in all cases.

Table 56. Mean monthly labour expenditures per animal unit in hours, enterprises stratified as to percent feeder animal units*

Month	Stratum 1 0-9.9%	Stratum 2 10-19.9%	Stratum 3 20.55.3%
January	3.6	2.1	1.8
February	3.7	2.1	1.8
March	4.9	2.0	2.1
April	4.5	3.3	3.0
May	4.6	3.3	2.5
June	2.0	2.2	1.0
July	5.2	5.3	4.4
August	3.3	1.8	1.7
September	2.3	2.4	2.9
October	2.9	2.0	2.1
November	3.9	2.5	2.2
December	3.6	2.1	1.6

*Strata means not tested for differences.

APPENDIX E

Table 57. Value farmers attached to major feed inputs at interview time.

Input	Mean	Std. error	Range	N
Oats ¢/bu.	56	1.3	40-68	27
Barley ¢/bu.	86	2.2	65-100	23
Wheat ¢/bu.	110	-	90-120	3
Legume hay $/ton	18.1	0.78	12.0-27.0	24
Tame grass hay $/ton	17.9	1.37	10.0-25.0	10
Cereal hay $/ton	15.7	1.32	9.0-27.0	14
Cereal straw $/ton	7.4	0.48	2.0-12.0	25

Table 58. Operators' estimates of value of land in dollars per acre*

Cultivated land

Stratum	1	2	3	4	Pooled
Mean	53	56	42	40	48
Std. error	3.9	4.4	2.3	5.4	2.3
N	10	10	8	10	38

Uncultivated land

Stratum	1	2	3	4	Pooled
Mean	9.9	10.6	5.3	5.8	8.6
Std. error	2.9	3.4	2.3	1.3	1.5
N	8	9	3	7	27

*Strata means not tested for significant differences.

The following table reports the data tabulated from the replies received on questions 30 and 31 in the questionnaire, Apendix A.

When asked if pasture could be rented within a distance that would be agreeable, 23 replied in the affirmative, six gave no as an answer, and 15 provided no information.

When asked what a fair rental rate for pasture would be, the author believes many operators gave replies that were biased downwards. The figures also lacked comparability because often answers were given which referred to a certain quality of pasture. Also comparability was lacking because privately owned pasture rentals were often confused with those rates available in community pastures and private leases.

Table 59. Pasture rental rates in dollars per month for a cow and calf

Going rate for pasture in area

Stratum	1	2	3	4	Pooled
Mean	-	-	-	-	1.7
Range	-	-	-	-	1.0-3.0
N	-	-	-	-	8

Fair rental rate for pasture

Stratum	1	2	3	4	Pooled
Mean	2.3	2.1	2.1	2.3	2.2
Range	1.5-5.0	1.0-5.0	0.5-5.0	1.5-4.3	0.5-5.0
N	8	5	7	8	28

APPENDIX F

In some cases the mode is useful for planning purposes, for it defines the most frequently observed value. The mode reported in this study had been calculated as being at the mid-point of the modal class. The mode was more stable and less sensitive to sampling variations than the mean.

If available, the range of observations would be useful for certain measures, for example, the number of days that cows had to be fed hay each year for the past fifty years. For many data sets the range was not reported because it was dependent upon only two value in the set, making it sensitive to sampling fluctuations.

Wherever variance was used, it was an estimate of the population parameter since N-1 degrees of freedom had been used.

The estimated population variance was defined as

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N-1}$$

where N was the number of observations, $\bar{x}$ was the arithmetic mean of observed values x_i for i = 1, 2, ..., N.

The standard deviation was the square root of the population variance, and the estimated standard error of the mean was given as

$$\hat{\sigma}_x = \hat{\sigma}/N^{1/2}$$

The coefficient of variation was presented as a percentage and was the ratio of the standard deviation to the mean. Thus $C/V = 100\hat{\sigma}/\bar{x}$.

To test the major hypothesis, different sized beef operations organize their resources differently, the main statistical tool used was the t-test for significance of difference of means for small samples. Since this test was dependent on the assumption that the two samples being tested came from populations with the same variance, one should be satisfied that the assumption is reasonable. The hypothesis that the variances were the same was tested by examining the distribution of F where F was the ratio between the two estimates of population variance, namely $\hat{\sigma}_1^2/\hat{\sigma}_2^2$.[80]

The value of t for testing significance of difference of means was found by calculating

$$t = \frac{\bar{x}_1-\bar{x}_2-(\mu_1-\mu_2)}{\left[N_1\hat{\sigma}_1^2 + N_2\hat{\sigma}_2^2/N_1N_2\right]^{1/2}}$$

where $\bar{x}_1$, $\hat{\sigma}_1^2$, and N_1 were the mean, estimated population variance and number of observations, respectively, for the first sample and $\bar{x}_2$, $\hat{\sigma}_2^2$, and N_2 were the corresponding values for the second sample. If the null hypothesis was that there was no difference between the population means μ_1 and μ_2, then $\mu_1 - \mu_2 = 0$.[81] An occasional test was made to determine whether any one mean was significantly different than zero.

In analysis of data concerned with management practices where all that could be said was that an operator did or did not engage in a

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80 See Kenney, J.F. and Keeping, E.S. Mathematics of Statistics. 3rd ed. New York, N.Y., D. Van Nostrand Company, Inc. 1954. p. 188.

81 Ibid., pp. 184-186.

certain practice, tests were made by the use of contingency tables for significance of difference between sample proportions.[82] For small samples

$$t = \frac{p_1 - p_2}{\left[\theta(1-\theta)\left(\frac{1}{s_1}+\frac{1}{s_2}\right)\right]^{1/2}}$$

where s_1 and s_2 were the two sample sizes (number of individuals within each stratum); $p_1 = x_1/s_1$, $p_2 = x_2/s_2$ when x_1 and x_2 were the number of individuals in each stratum engaged in that practice and θ was the true proportion of x in the population. The over-all proportion of operators engaged in the practice was taken as the best estimate of θ.[83]

As the secondary objective this study was concerned with the fitting of a function to the input-output data collected, the statistical procedures to be adopted are outlined here. Moreover, a number of important aspects involved in functional derivation were given brief consideration.[84]

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[82] Procedure Ibid., pp. 301-302, 169-173.

[83] See "Practices" section of this study p. 70.

[84] Many reference sources are available. Those consulted include: Heady and Dillon. Agricultural Production Functions. op.cit. Ezekial, Mordecai and Fox, Karl A. Methods of Correlation and Regression Analysis. 3rd ed. New York, N.Y., John Wiley & Sons, Inc. 1959. Huntsberger, David V. Elements of Statistical Inference. Boston, Mass., Allyn and Bacon, Inc. 1963. Kenney and Keeping, op.cit. Fox, Karl A. Econometric Analysis for Public Policy. Ames, Iowa, Iowa State University Press, 1960.

The use of a single equation model employing the least squares regression technique was a commonly-taken approach when studying functional relationships of the type encountered in this study. Selection of the appropriate algebraic form remains partially a matter of judgment since the logic and basis for selection has been fully developed. Frequently the decision had been made on a number of practical grounds. The equation must conform to the logic of the problem, provide an adequate fit of the data, be computationally feasible and manageable in terms of testing the coefficients. In these respects the Cobb-Douglas function performed quite well and had been the most popular form in farm firm analyses. A further consideration of practical importance favored the Cobb-Douglas function when data collection was expensive and small samples were to be used. It allowed diminishing marginal returns to come into play without using as many degrees of freedom as would be required by a quadratic function.[85]

The Cobb-Douglas function conformed fairly well to economic logic, allowed decreasing marginal products and varying marginal rates of substitution. Since the iso-product contours became asymtotic to the axes, the function served best for factors that were substitutes within one range but technical complements in extreme ranges. The function forced linear isoclines, which for many situations may be unrealistic but for certain firm conditions -- the beef enterprise being one -- constant rates of factor substitution may be realistic

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[85] Tintner, Gerhard and Brownlee, O.H. Production Functions Derived from Farm Records. J. Farm Econ. 26:566-571. 1944.

if all inputs of the productive process were increased in approximately the same proportion when output was increased. It did not allow for negative marginal products so was not suitable for estimating productivities far from the mean values.

When using cross-sectional data for functional analyses, a number of assumptions were made which may not hold in the real world and biased coefficients resulted. For example, quality of capital, labour, and feed inputs were assumed to be homogeneous among firms since adjustments were rarely made for quality differences. Also one assumes that each farm operated on the same production function. If they did not, a hybrid function resulted.[86] Frequently the procedure assumed that output can be expressed as a function of the inputs selected. If the proper inputs were not selected, then causation may be assumed where it did not exist. Some variables may be known but were excluded because quantification was impractical. The classic example was management.

Griliches discussed bias in the Cobb-Douglas function.[87] A few of his conclusions follow:

> (1) If a variable is excluded which has some correlation with an included variable, one or more of the coefficients will be overestimated. In particular the omission of managerial inputs may bias the estimate of elasticity of output with respect to capital inputs upwards and estimates of the returns to scale downwards.

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[86] See Heady and Dillon, op.cit., p. 191 for a discussion of hybridity.

[87] Griliches, Zvi. Specification Bias in Estimates of Production Functions. J. Farm Econ. 39:8-20. 1957.

(2) Aggregation of inputs nearly always leads to bias unless by some happy accident the proper weighting is given each sub-input.

In order to minimize bias in aggregation Griliches suggested that inputs be aggregated that were used in fixed proportions or nearly so, but that inputs in one group should not be associated in fixed proportions with inputs in another group. Heady and Dillon agreed that perfect complements (resources used in fixed proportions) should be treated as a single input to avoid as far as possible the multi-collinearity problem.[88] Heady and Dillon suggested that independent variables which have correlation coefficients with values close to 1.0 and greater than 0.8 lead to problems of multicollinearity. In such cases one must aggregate or omit one of the highly correlated variables. The new coefficients may be satisfactory if the logic of the situation does not dictate that the omitted variable be included.[89]

The procedure used in fitting was to be that of stepwise regression in which at each stage the variable was added which accounts for the largest proportion of the remaining variation of the dependent variable. Functions were to be fitted linearly to the observed data and linearly to the logarithmic transformations of the observed data. The latter procedure generated the coefficients for the Cobb-Douglas function. The testing of the linear function was thought to be advisable because for the size range of beef operations examined, constant returns may prevail. The linear function did not, however,

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88 Heady and Dillon, op.cit., p. 220.

89 Ibid., p. 136.

conform well to economic logic as it forced constant marginal products and constant marginal rates of substitution.

At each stage of the stepwise regression the F ratio of the mean sum of squares due to regression to the mean sum of squares due to error was tested for significance. At each stage the value of t for each coefficient was calculated along with the proportion of the dependent variable explained by the last included variable (the R^2). At the final stage of regression each original observation was compared to each value estimated by the regression and the sum of squares of the differences was calculated $\Sigma(Y_i-\hat{Y}_i)^2$.

Some or all of the previously mentioned measures were considered. In their discussion of the problem Heady and Dillon indicated a number of criteria that were used. Workers were to select functions: (1) using previous knowledge of the relationships; (2) by retaining all coefficients even if they seemed to add little to the relationship; (3) by retaining only those coefficients that were significant at a five percent level; (4) by measuring fit or lack fit using R^2 or the smaller mean square of deviations from regression; (5) by omitting variables if the standard error of the regression coefficient exceeded the coefficient itself.[90] The only conclusion possible was that experience and judgement were required in selecting appropriate functions.

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90 Ibid., pp. 102-107.

Table 60. Correlation coefficients of aggregated variables on a total enterprise and per animal unit basis for both arithmetic and logarithmic values

Total enterprise--arithmetic

	Y_2	X_1	X_2	X_3	X_4	X_5	X_6
Y_1	0.98	0.95	0.89	0.70	0.59	0.43	0.88
Y_2		0.95	0.90	0.73	0.63	0.41	0.90
X_1			0.95	0.63	0.49	0.44	0.83
X_2				0.57	0.50	0.43	0.81
X_3					0.44	0.34	0.83
X_4						0.14	0.63
X_5							0.43

Total enterprise--logarithmic

	Y_2	X_1	X_2	X_3	X_4	X_5	X_6
Y_1	0.98	0.92	0.89	0.51	0.34	0.23	0.90
Y_2		0.95	0.92	0.52	0.42	0.22	0.91
X_1			0.95	0.39	0.40	0.16	0.87
X_2				0.35	0.46	0.23	0.85
X_3					0.23	0.15	0.63
X_4						0.19	0.39
X_5							0.25

Per animal unit[a]--arithmetic

	Y_2	X_1	X_2	X_3	X_4	X_5	X_6
Y_1	0.87	-	0.07	0.57	-0.10	0.30	0.49
Y_2		-	0.14	0.61	-0.10	0.21	0.49
X_1			-	-	-	-	-
X_2				-0.09	0.36	0.28	0.16
X_3					0.01	0.16	0.73
X_4						0.21	0.16
X_5							0.36

Table 60 (continued)

Per animal unit--logarithmic

	Y_2	X_1	X_2	X_3	X_4	X_5	X_6
Y_1	0.90	-	0.12	0.43	0.04	0.23	0.50
Y_2		-	0.17	0.49	0.06	0.20	0.50
X_1			-	-	-	-	-
X_2				0.00	0.25	0.27	0.23
X_3					0.25	0.13	0.67
X_4						0.20	0.36
X_5							0.26

[a]Per animal unit variables are generated by dividing each farm observation by the number of animal units on the farm.

Table 61. Coefficients, t-values, and contribution to R^2 for two linear equations, one on a total enterprise basis and the other on a per animal unit basis for 37 Peace River beef enterprises

Total enterprise[a]

Variables[b]	X_1	X_2	X_3	X_4	X_6
Coefficient[c]	36.0	ns[d]	10.7	0.58	0.40
t	10		1.9	3.4	1.2
R^2 (%)	89.8		0.5	1.2	4.3

Per animal unit[e]

	X_1	X_2	X_3	X_4	X_6
Coefficient[f]	na[g]	4.32	19.1	-0.11	ns[h]
t	-	1.9	4.8	1.4	
R^2 (%)	-	3.6	36.7	3.2	

[a]Output of beef is in units of 10 pounds per farm.

[b]X_1 denotes number of beef animal units per farm. X_2 denotes tons of TDN roughage fed to beef per farm. X_3 denotes tons of TDN concentrate fed to beef per farm. X_4 denotes hours of labour spent on the beef enterprise per farm. X_6 denotes dollars of variable costs on the beef enterprise per farm.

[c]Value of constant 'a' is -487.

[d]Variable X_2 was deleted from the equation for non significance (see page 90)

[e]Output of beef is in units of 10 pounds per animal unit. Input variables are on the animal unit basis.

[f]Value of constant 'a' is 33.4.

[g]Not applicable.

[h]Variable X_6 was deleted from the equation for non significance.